
Research Report
KTC 93-6

INSTALLATION AND PERFORMANCE
OF PORTLAND CEMENT CONCRETE
PAVEMENT JOINT SEALERS

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February 1993

METRIC CONVERSION FACTORS									
APPROXIMATE CONVERSIONS TO METRIC UNITS					APPROXIMATE CONVERSIONS FROM METRIC UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol	Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH					LENGTH				
in	inches	25.4	millimetres	mm	mm	millimetres	0.039	inches	in
ft	feet	0.305	metres	m	m	metres	3.28	feet	ft
yd	yards	0.914	metres	m	m	metres	1.09	yards	yd
mi	miles	1.61	kilometres	km	km	kilometres	0.621	miles	mi
AREA					AREA				
in ²	square inches	645.2	millimetres squared	mm ²	mm ²	millimetres squared	0.0016	square inches	in ²
ft ²	square feet	0.093	metres squared	m ²	m ²	metres squared	10.764	square feet	ft ²
yd ²	square yards	0.836	metres squared	m ²	ha	hactares	2.47	acres	ac
ac	acres	0.405	hactares	ha	km ²	kilometres squared	0.386	square miles	mi ²
mi ²	square miles	2.59	kilometres squared	km ²					
VOLUME					VOLUME				
fl oz	fluid ounces	29.57	millilitres	mL	mL	millilitres	0.034	fluid ounces	fl oz
gal	gallons	3.785	litres	L	L	litres	0.264	gallons	gal
ft ³	cubic feet	0.028	metres cubed	m ³	m ³	metres cubed	35.315	cubic feet	ft ³
yd ³	cubic yards	0.765	metres cubed	m ³	m ³	metres cubed	1.308	cubic yards	yd ³
MASS					MASS				
oz	ounces	28.35	grams	g	g	grams	0.035	ounces	oz
lb	pounds	0.454	kilograms	kg	kg	kilograms	2.205	pounds	lb
T	short tons (2000 lb)	0.907	megagrams	Mg	Mg	megagrams	1.102	short tons (2000 lb)	T
TEMPERATURE (exact)					TEMPERATURE (exact)				
°F	Fahrenheit temperature	(°F-32)/1.8	Celsius temperature	°C	°C	Celsius temperature	(1.8°C) + 32	Fahrenheit temperature	°F

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EXECUTIVE SUMMARY

Joints are needed in portland cement concrete pavements to control cracking, relieve pavement stresses due to volume change, and to protect immovable structures. However, when the joints are not properly designed, constructed, and maintained, they may become a source of multiple problems. It is the opinion of many pavement management engineers that the most effective way to prevent and/or correct problems with joints is to use a joint sealer material. The purpose of the sealer is to keep surface water and fine, incompressible material from entering the pavement joint.

The Kentucky Transportation Center was contracted by the Kentucky Department of Highways to evaluate the installation and short-term performance of four different types of joint sealants used for portland cement concrete pavements. The four cement concrete pavement joint sealers used in the project were: silicone rubber, self-leveling silicone rubber, preformed polychloroprene compression seal, and conventional hot-poured elastic sealant. The silicone sealants were supplied for the project by the DOW Corning Company. The preformed polychloroprene compression seals were supplied by the D. S. Brown Company.

The silicone rubber sealant was sticky, difficult to install properly, and subsequently, is displaying evidence of increased wear. The self-leveling silicone rubber sealant was more fluid, less sticky, easier to install, obtained the correct depth in the joint most consistently, and has performed extremely well to date. The preformed polychloroprene compression seals appeared to be easily installed. However, uniformity in depth below the surface of the joint was not achieved and twisting of some seals was observed. A greater amount of incompressible materials are collecting in the pavement joints containing the preformed polychloroprene compression seals. The hot-poured elastic joint sealer was easily installed but installers had difficulties controlling the rate of application.

It was concluded that with proper construction techniques, successful applications of silicone rubber joint sealers will result. The silicone sealants provide an effective means of preventing moisture and incompressible fines from entering the pavement joint. Based on this successful initial application and the excellent short-term performance exhibited thus far, it was recommended that self-leveling silicone rubber sealant be used on a number of additional projects so that a more extensive performance data base may be developed by the Department of Highways.

INTRODUCTION AND BACKGROUND

Joints are needed in portland cement concrete pavements to control cracking, relieve pavement stresses due to volume change, and to protect immovable structures. However, when the joints are not properly designed, constructed, and maintained, they may become a source of multiple problems [1]. It is the conviction of many pavement management engineers that the most effective way to prevent and/or correct problems with joints is to use a pavement joint sealer material. The purpose of the sealer is to keep surface water and fine, incompressible material from entering the pavement joint.

To further quantify the effectiveness of joint sealers to prevent the intrusion of surface water and incompressible material into cement concrete pavement joints, the Kentucky Department of Highways requested that Kentucky Transportation Center (KTC) investigators evaluate the performance of various types of concrete pavement joint sealers. Specifically, the objective was to evaluate the installation procedures and short-term performance of the various cement concrete pavement joint sealers and compare the data to other data stemming from previous usage of cement concrete pavement joint sealers.

Kentucky Department of Highways' officials selected four different types of joint sealer material for the comparisons. The various cement concrete pavement joint sealer types used were evaluated and compared directly for performance. The cement concrete pavement joint sealers evaluated were: silicone rubber sealant, self-leveling silicone rubber sealant, hot-poured elastic joint sealer, and, preformed compression joint sealer. Silicone rubber sealant and hot-poured elastic joint sealers are field-molded sealants and are formed into the required shape within the mold provided at the joint opening. On the other hand, preformed compression sealants are functionally preshaped during manufacturing so that only a minimum of site fabrication is necessary for installation. Specifications for the respective cement concrete pavement joint sealers are contained in Appendix A. Installation requirements for the various sealers for cement concrete pavement joints also are contained in Appendix A. Standard drawings illustrating joint details for the various cement concrete pavement joint sealers are contained in Appendix B.

INSTALLATION PROCEDURES AND OBSERVATIONS

The experimental installation was located in Franklin County on US 127, Cedar Cove Hill Road (Figure 1). The experimental section was a newly constructed portland cement

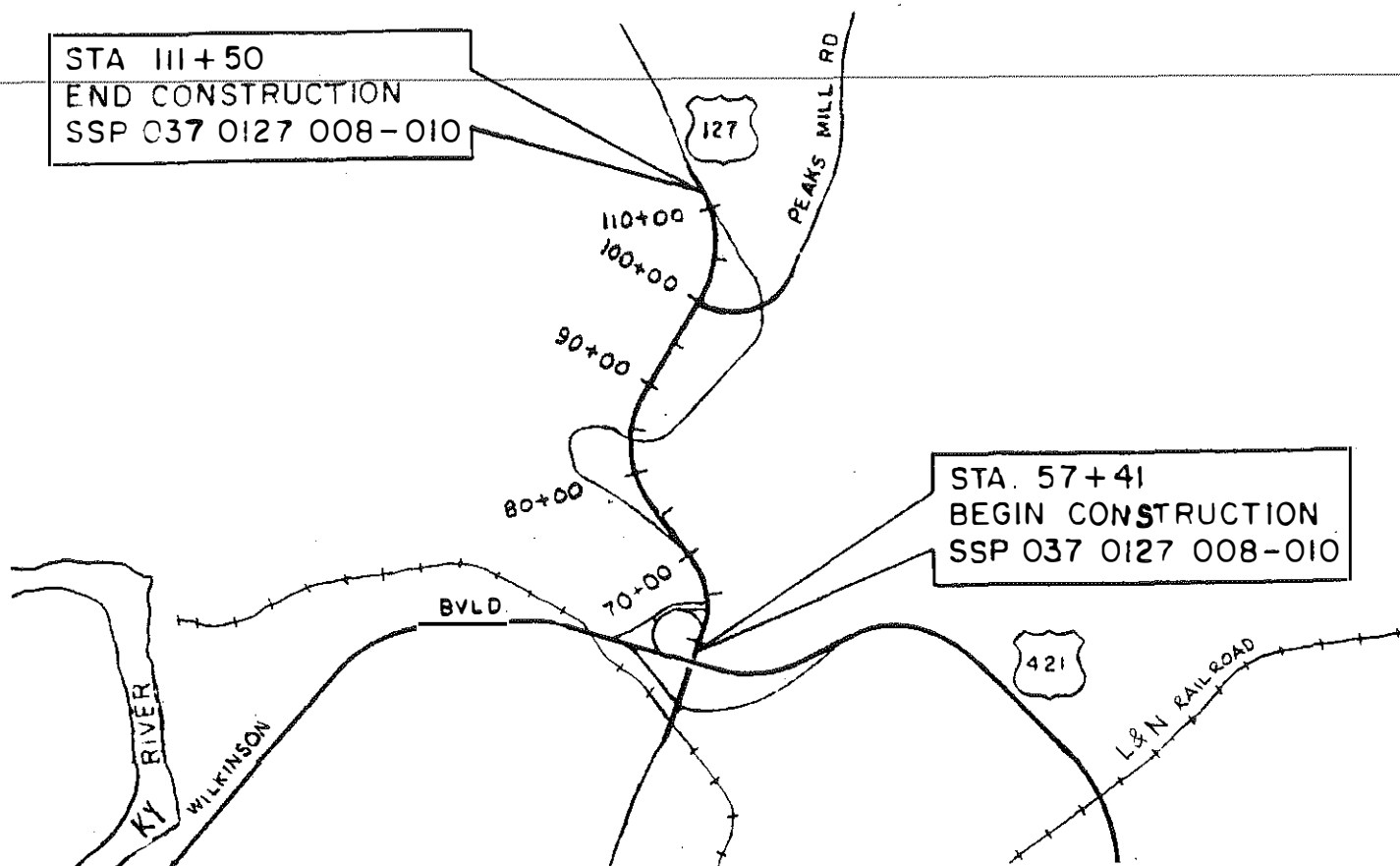


Figure 1. Location of project.

concrete pavement extending from Station 66+50 to Station 107+50. A large portion of the experimental site was located on a seven percent grade. The subcontractor, Shamrock Construction Company, was responsible for placement of the cement concrete, sawing and cleaning of the cement concrete pavement joints, and sealing the cement concrete pavement joints. The jobsite was divided into two sections. Section one was located between Station 85+50 and Station 107+50. Section two extended from Station 66+50 to Station 85+50. Placement locations for the different materials are given in Table 1. Construction of the concrete pavement took place during the early summer months of 1990.

The cement concrete pavement was placed, finished, cured, and joints were sawed to control shrinkage cracking. The pavement joints then were re-sawn to the correct joint size prior to installing the cement concrete pavement joint sealers. Typically, longitudinal pavement joints were sawn 1/4-inch wide and transverse joints were sawn 1/2-inch wide. All construction joints were 5/8-inch wide. The installation procedures that followed this activity varied for the different joint treatment material types and are described herein.

TABLE 1. JOINT TYPES AND LOCATION OF SEALANTS

Sealant Type	Beginning Station	Ending Station	Pavement Joint Type
Silicone Rubber	STA 79+00	STA 85+50	All
	STA 93+00	STA 105+50	All
	STA 85+50	STA 93+00	All (Truck Lane Only)
Self-Leveling Silicone Rubber	STA 73+00	STA 79+00	All
	STA 85+50	STA 93+00	All (Except Truck Lane)
Polychloroprene	STA 66+50	STA 73+00	Transverse and Centerline
	STA 105+50	STA 107+50	Transverse and Centerline
Hot-Poured Rubber	STA 66+50	STA 73+00	Construction
	STA 105+50	STA 107+50	Construction

Silicone Rubber Sealant and Self-Leveling Silicone Rubber Sealant

After the pavement joints were re-sawn, they were flushed using water under high pressure. This activity was performed before the paste residue resulting from the saw cut had time to harden. After the pavement joints were flushed, another saw cut was made to set a 3/16-inch bevel on each side of the pavement joint. Some of the beveled joint edges, especially those of the construction joints, were noticeably uneven due to the unevenness of the pavement at the construction joint. The pavement joint faces were then sandblasted and the backer material was placed in the pavement joint at the specified depth. A wheel having a raised center was used to set the backer material to the correct depth (see Figure 2). Both silicone sealant types were placed using an applicator that had an air hose mounted at the front of the application wand (see Figure 3). This configuration was used to clear the joint of any foreign material that may have accumulated prior to placing the silicone sealant.

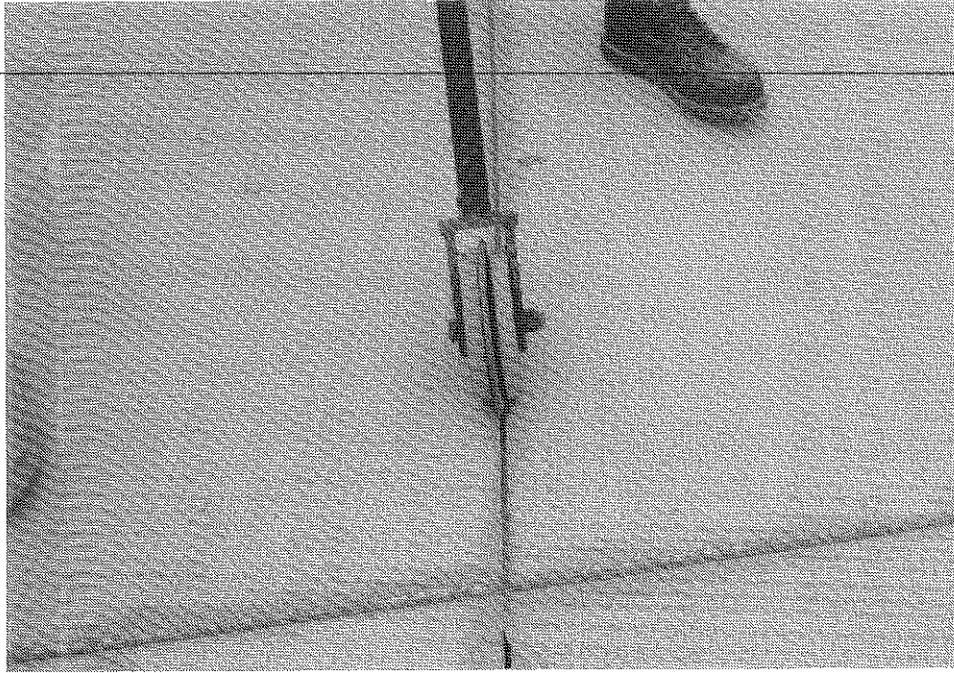


Figure 2. *Wheel having raised center used to position backer material in the pavement joint.*



Figure 3. *Application wand used to install silicone products.*

After the silicone rubber sealant was placed, a tool made from PVC pipe (3/4-inch elbow with an 8-foot handle) was used to smooth the surface. A photograph of this device is shown in Figure 4. Workers also tried to use a piece of backer material to smooth the joint and, as shown in Figure 5, frequently resorted to using their fingers to tool the silicone rubber sealant. There was no tooling required for the self-leveling silicone rubber sealant.

There were several problems observed during installation of the silicone rubber products. Because the backer material was pressed into the joint using a wheel having a raised center, the backer material often was located too high in the joint in those areas where the pavement was uneven, especially at the construction joints. Also, when the pavement joint was too wide, the air hose on the applicator wand would often blow the backer material too far down into the pavement joint causing the backer material to be too low in the joint. Plug samples obtained from the cured silicone rubber sealant ranged from the correct thickness of 1/4 inch to as much as 3/4 inch (see Figure 6). It was observed during the installation of both silicone rubber products that when the person operating the applicator wand could master the rate of flow and keep a steady pace, a smooth joint seal generally resulted.

Placement of the silicone rubber sealant was often messy, the depth of the sealant in the pavement joint was very irregular, and a substantial amount of time was devoted to tooling silicone rubber sealant. The silicone rubber sealant was stickier and more difficult to install than the self-leveling silicone rubber sealant. The crew installing the silicone rubber sealant had difficulties keeping it off the pavement surface. The excess material was wasted and an inordinate amount of time for cleanup and tooling was required. In some instances, a laborer had to use a shovel to push the fabricated finishing tool through the pavement joint because there was too much sealer in the joint and on the pavement surface itself (see Figures 7 and 8).

The self-leveling silicone rubber sealant was observed to flow around the backer material where the pavement joint had a crooked, or uneven, sawcut. The self-leveling sealant would fill the void under the backer material leaving the surface of the seal too low in the pavement joint in that spot. It was noted that when air temperatures were greater than 90°F, the self-leveling sealant appeared to flow uninhibited down the seven percent grade. Overall, the self-leveling silicone sealant was installed much more easily and was easier to work with than the silicone rubber sealant, primarily because no additional tooling was required to finish the surface.

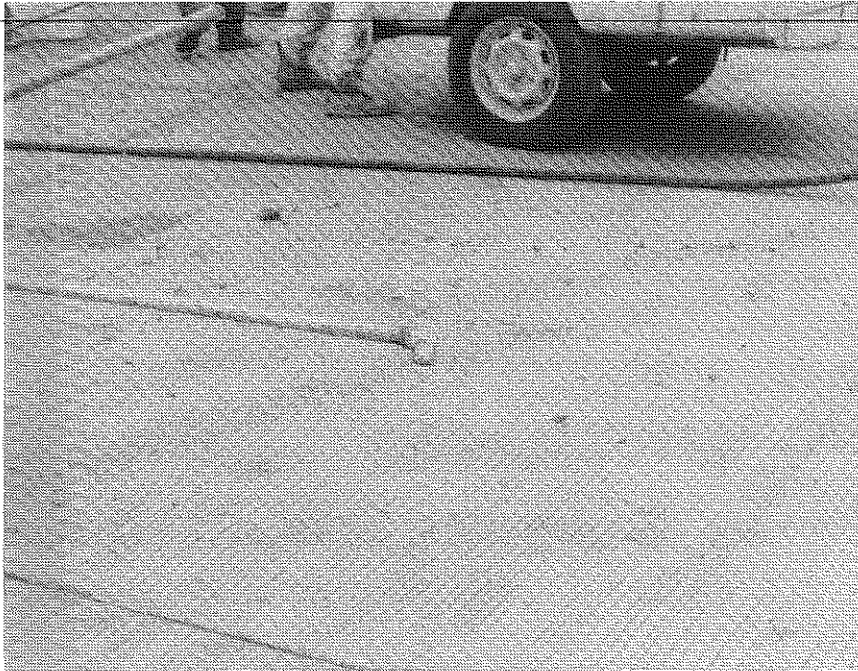


Figure 4. *Instrument used to smooth the silicone rubber sealant.*



Figure 5. *Workers sometimes used their fingers to tool the silicone rubber sealant.*

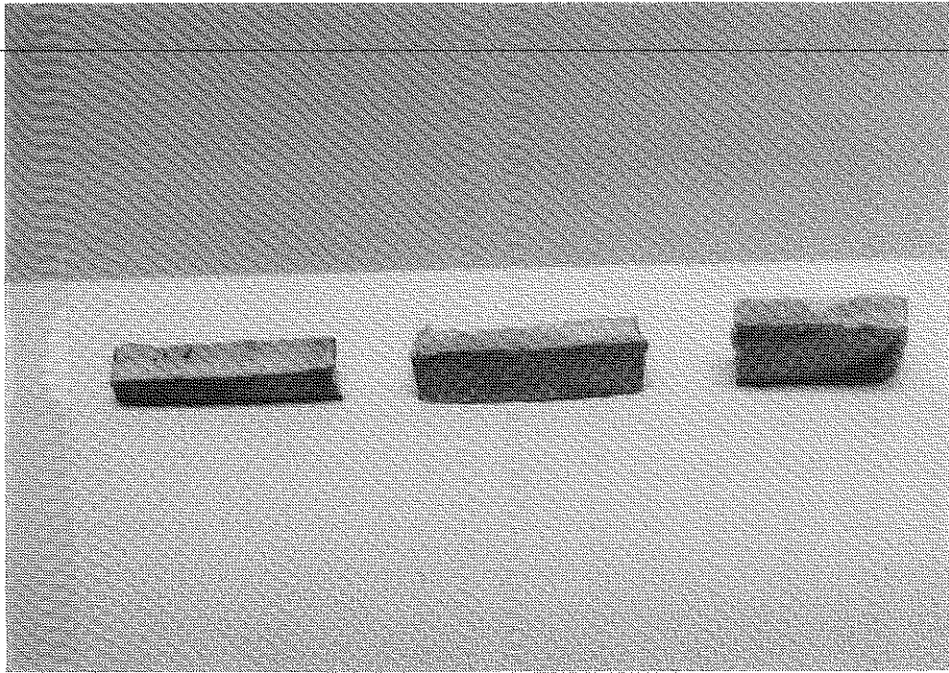


Figure 6. *Plug samples obtained from pavement joints filled with the silicone rubber sealant revealed varying sealant thicknesses.*



Figure 7. *Installation of the silicone rubber sealant required significant tooling and clean up.*

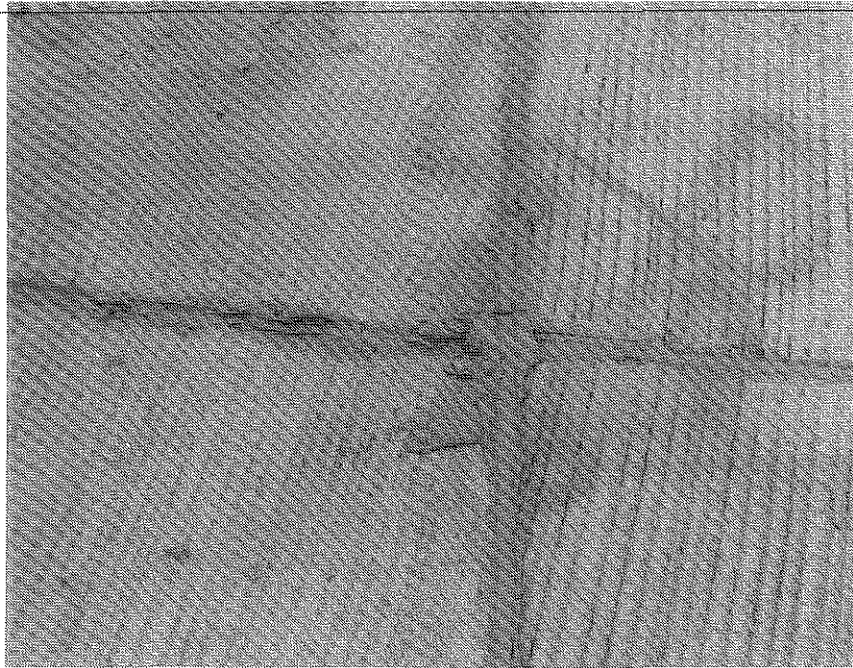


Figure 8. *Excess material in the pavement joint filled with the silicone rubber sealant.*

Hot-Poured Elastic Sealant

Hot-poured elastic sealant was used in all construction joints within the polychloroprene seal sections. The hot-poured elastic sealant was installed at a temperature of 400°F +/- 15°F. Placement of the hot-poured elastic sealant was performed by two men. One man drove the truck containing the liquid material and the other man operated the applicator. Further finishing of the hot-poured elastic sealant was not required after it was installed.

The hot-poured elastic sealant was extremely liquid during its placement. The highly liquid sealant would flow into a large void leaving the sealant too low in the pavement joint. In one instance, this problem was called to the attention of the inspector and the pavement joint was refilled to the proper depth. The hot-poured elastic sealant exhibited difficulties similar to those encountered with the silicone rubber sealant products. The rate of flow of the sealant had to be rigorously controlled or the installation appeared ineffective. In many of the construction joints, the hot-poured elastic overfilled the joint and no attempt was made to clean the excess material from the pavement surface.

Preformed Polychloroprene Compression Seal

After the pavement joints were re-sawn, they were flushed with water under high pressure. A 3/16-inch bevel was cut on each side of the pavement joint. This operation was identical to the procedure used for the silicone sealant sections. After the pavement joint edges were beveled, the pavement joint was cleaned with compressed air. A specially designed machine was then used to lubricate and simultaneously push the preformed polychloroprene compression seal down into the pavement joint.

The primary obstacle observed during installation of the preformed polychloroprene compression seal was the inability to satisfactorily achieve constant depth of the seal with the pavement joint. Apparently, it was very difficult to consistently position the seal within the joint at a uniform depth. Therefore, some seals were located higher within the joint, some were located very low within the pavement joint, and some seals were at the correct depth. It was thought that the inconsistent depth of the seals was attributable to the transverse tying of the concrete pavement and the fact that the pavement joints were on a skew. The specially designed machine could have been moving up and down during the installation of the compression seals as it traversed across the tynd marks on the pavement surface. However, some of the compression seals were located very deep within the pavement joint.

PERFORMANCE

The purpose of a pavement joint sealer is to keep surface water and fine incompressible material from entering the joint. Generally, all pavement joint sealers are performing effectively thus far where the pavement joint was in good condition. Ineffective seals, irregardless of whether the joint sealant was silicone or hot-poured, were observed most often at construction joints, principally between the travel lane and shoulder. Figure 9 depicts a deteriorated construction joint between the southbound travel lane and shoulder near Station 91+00 in the section containing pavement joints filled with the self-leveling silicone rubber sealant. There are numerous instances of this type of failure throughout the jobsite. These failures of the pavement joint are typically impact spalls. Sawing the joint generally eliminates impact spalling at pavement joint faces but not in this instance. It is the authors' opinion that higher water/cement ratios at the construction joints left the concrete weakened in those areas which lead to the observed joint spalling.

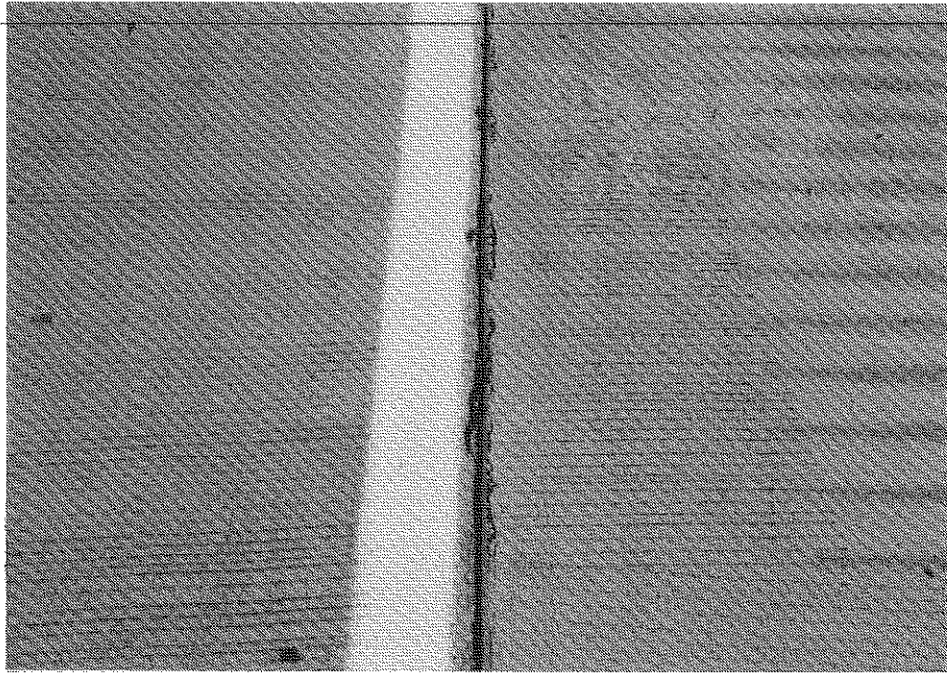


Figure 9. *Deterioration of construction joint near Station 91+00. Pavement joint is filled with self-leveling silicone rubber sealant.*

Remedial work should be performed to prevent surface water and fine incompressible material from entering the construction joint. Figure 10 illustrates a deteriorated transverse construction joint in the southbound lanes near Station 93+00 in the section containing pavement joints filled with silicone rubber sealant. Another type of failure was observed in an area where corrective work had been performed so that the concrete pavement would meet pavement smoothness requirements. Unfortunately, as shown in Figure 11, this grinding action on the pavement surface initiated deterioration of the pavement joint and destroyed the integrity of the silicone rubber sealant. According to subsection 501.23.01 of the Kentucky Department of Highways' Standard Specifications for Road and Bridge Construction, smoothness requirements must be met prior to placing any joint seals on new portland cement concrete pavement unless otherwise permitted in writing, which must have occurred on this project. Remedial work should be performed within those pavement areas that were ground to meet smoothness requirements so as to restore the effectiveness of the pavement joint sealant.

The overall appearance and performance of the self-leveling silicone rubber sealant is, to date, superior to the comparative sealant materials. The self-leveling silicone rubber

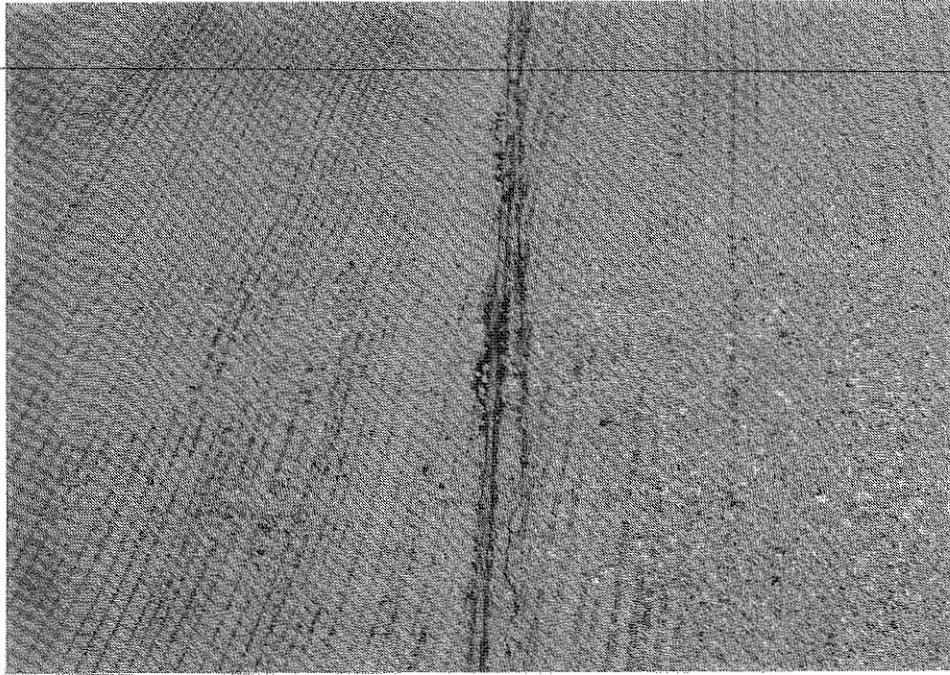


Figure 10. *Deterioration of transverse construction joint filled with silicone rubber sealant near Station 93+30.*

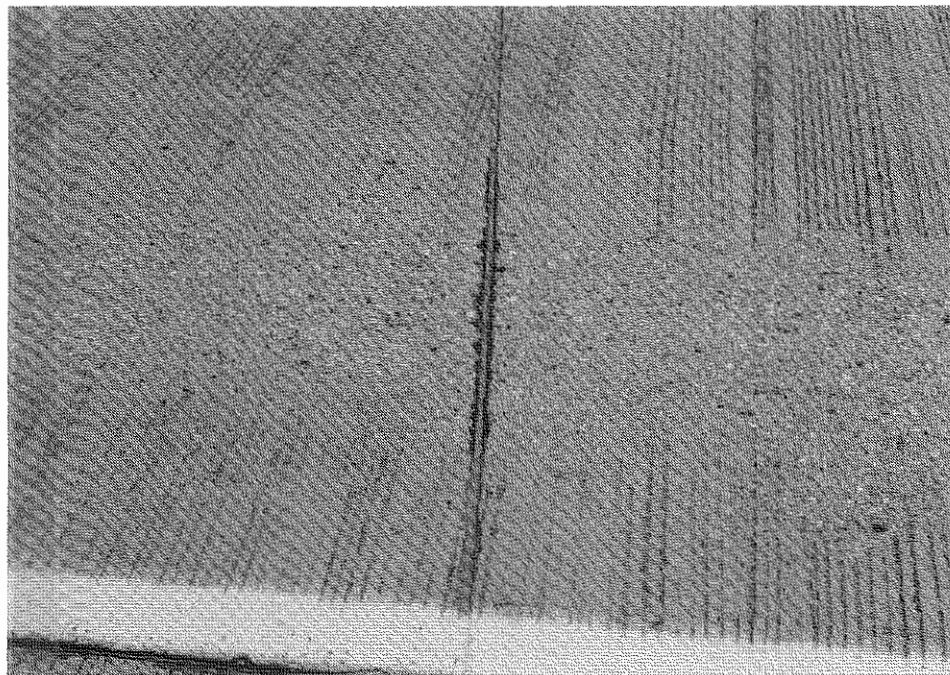


Figure 11. *Deterioration of a transverse joint filled with self-leveling silicone rubber sealant due to corrective work performed on the pavement surface near Station 100+20.*

sealant exhibits a good finish and has no discernible problems. The self-leveling silicone rubber pavement joint sealant is very uniform and is consistently closer to the correct depth within the pavement joint than any of the other joint sealant materials. Sealant failure due to poor adhesion of the sealant to the joint face has not been observed thus far.

The silicone rubber sealant was much more difficult to install than was the self-leveling silicone product. There were particular problems because excess silicone rubber sealant contaminated the pavement surface. The excess silicone rubber sealant is being worn away under the action of traffic. The excess silicone rubber sealant has not resulted in any detectable localized failures of the sealant as may be expected. The action of traffic, combined with unclean joint faces during sealant installation, is suspected of causing previous silicone rubber sealant failures on I-471. Because of the absence of any failures of the silicone rubber sealant on this project, it may be concluded that exceptional effort was devoted to cleaning and preparing the cement concrete pavement joint surfaces prior to the placement of the pavement joint sealant materials. However, the overall appearance of the surface of the silicone rubber sealant is poorer than the self-leveling silicone rubber sealant. The surface of the silicone rubber sealant is rough and the depth of the sealant from the pavement surface is not as consistent as that observed in the pavement joints filled with the self-leveling silicone rubber.

The preformed polychloroprene compression sealer installed longitudinally along the centerline is performing effectively. Transverse joints containing the preformed polychloroprene joint seals are apparently performing effectively but are exhibiting a significantly larger buildup of incompressible material in the pavement joint than those pavement joints containing the silicone rubber, self-leveling silicone rubber, and hot-poured elastic joint sealant products. The fact that the performed polychloroprene appeared to be positioned too low within the joint is contributing to this phenomenon. The shape of the compression seal also may be contributing to the accumulation of incompressible fines. The buildup of incompressible fines could cause future spalling of the joint. Figure 12 illustrates the accumulation of incompressible fines in the pavement joints having polychloroprene compression seals. Areas of the pavement where the preformed polychloroprene compression seal was positioned higher in the pavement joint are not exhibiting the large buildup of incompressible materials and appear to be performing much better. Twisting of the polychloroprene compression seal has been observed in only a few of the transverse pavement joints. Twisted compression seals are considered failures. Figure 13 depicts a twisted compression seal.

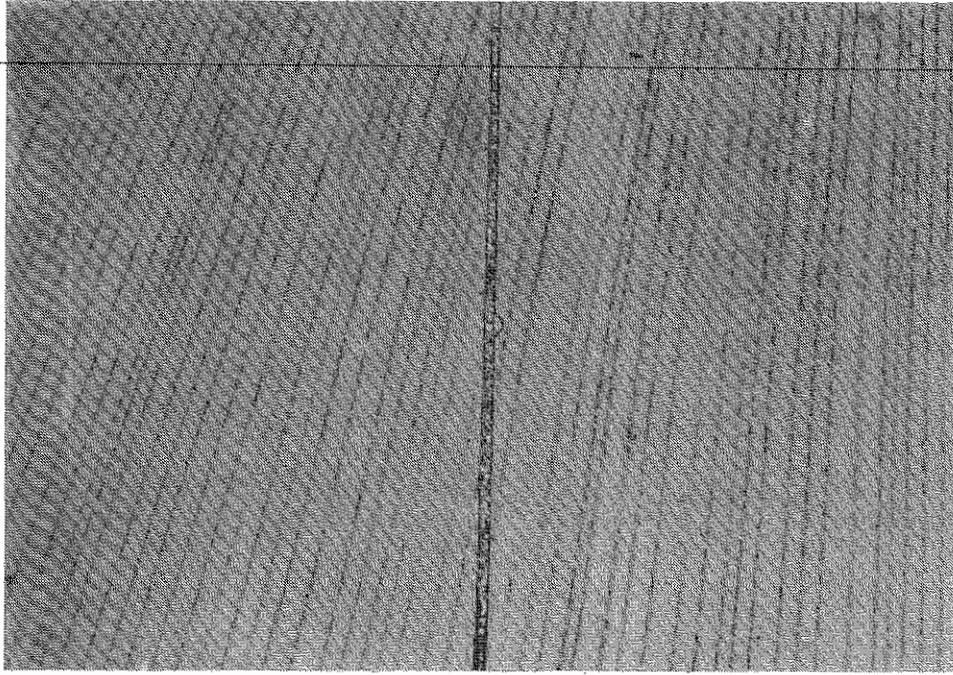


Figure 12. *Pavement joints having polychloroprene compression seals exhibit a large accumulation of incompressible fines.*

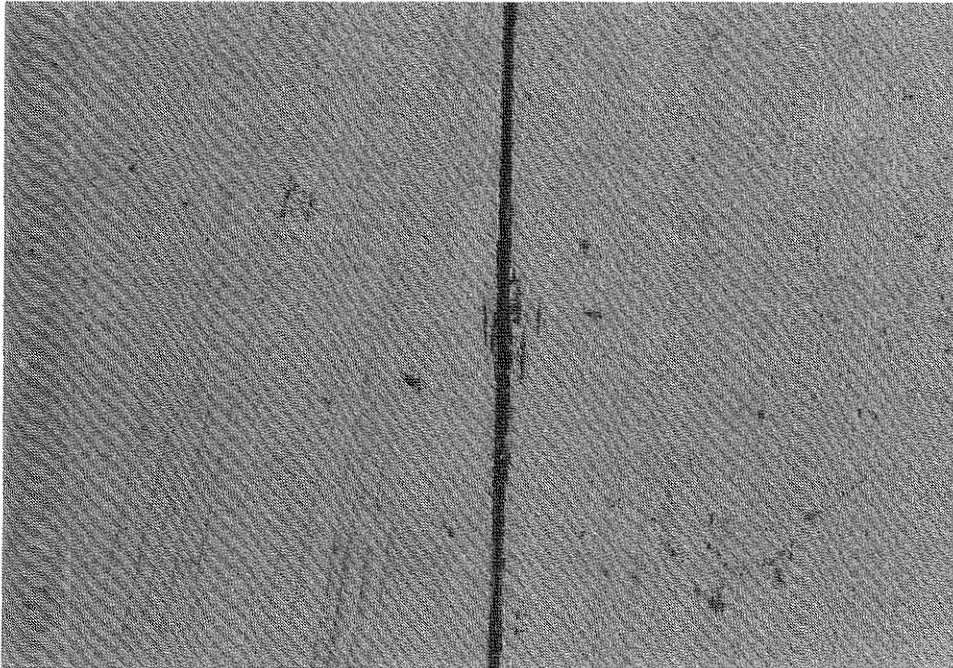


Figure 13. *This polychloroprene compression seal was twisted within the pavement joint.*

The appearance of the hot-poured elastic joint sealer is not satisfactory due to the depth from the surface in some areas and material overruns in other areas (see Figure 14). However, the hot-poured elastic sealer appears to be performing effectively and continues to be very pliable nearly three years after installation. It should be reiterated that the hot-poured elastic sealer is located only in construction joints within the polychloroprene compression seal sections. The hot-poured elastic sealant generally will not be subjected to the traffic action as that of other sealant products.

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The Kentucky Transportation Center was contracted by the Kentucky Department of Highways to evaluate the installation and short-term performance of four different types of joint sealants used for portland cement concrete pavements. The four cement concrete pavement joint sealers used in the project were: silicone rubber sealant, self-leveling silicone rubber sealant, preformed polychloroprene compression seals, and conventional hot-poured elastic sealant.



Figure 14. *The hot-poured elastic sealant was observed to overfill and underfill the pavement construction joint.*

The silicone rubber sealant was sticky, difficult to install properly, and subsequently, is displaying evidence of increased wear. The self-leveling silicone rubber sealant was less viscous, less sticky, easier to install, obtained the correct depth in the joint most consistently, and has performed extremely well to date. The preformed polychloroprene compression seals appeared to be easily installed. However, uniformity in depth below the surface of the joint was not achieved and some twisting of the seals has occurred. The preformed polychloroprene compression seals are not revealing any signs of increased wear. Nevertheless, more incompressible materials are collecting in those pavement joints that contain the preformed polychloroprene compression seals. Twisting failures of the compression seals also have been observed. The hot-poured elastic joint sealer was easily installed but installers had difficulties achieving the desired depth within the pavement joint. The hot-poured elastic joint sealer has not exhibited any evidence of significant wear thus far. Figure 15 illustrates one advantage of using field-molded sealants as opposed to preformed sealants. Human error, when re-sawing the joint, resulted in a non-specification joint width. The silicone sealant provides an effective seal whereas the compression seal would not in this instance.

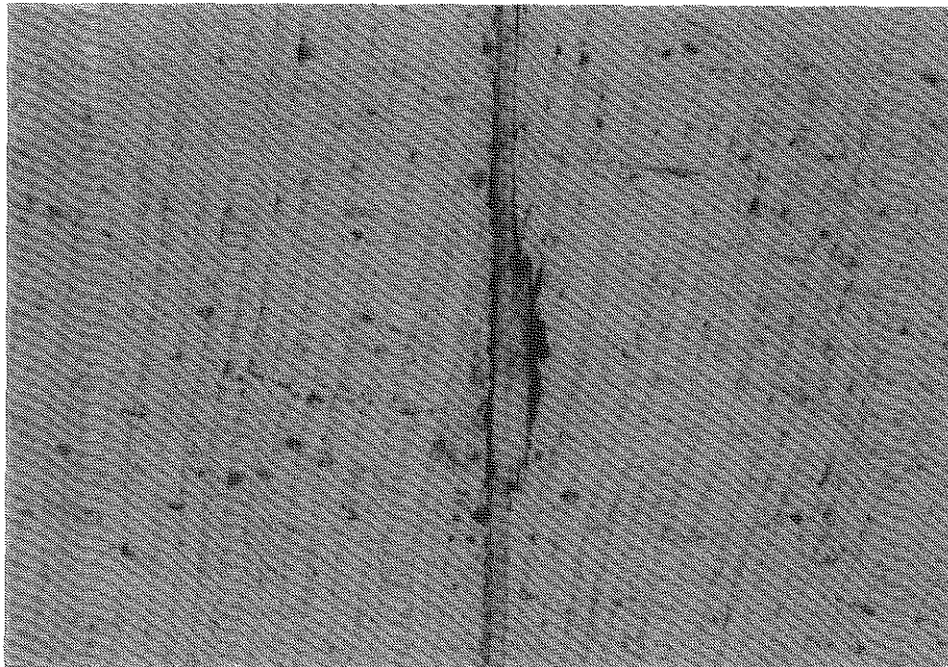


Figure 15. *Field-molded sealants may overcome deficiencies of non-specification joint widths.*

Kentucky Department of Highways' Standard Specifications for Road and Bridge Construction, Section 501.23 specifies the uses and requirements for sealing portland cement concrete pavements [2]. Preformed polychloroprene seals, hot-poured elastic joint sealer, and silicone rubber sealants may be used as specified. Typically, preformed polychloroprene seals are specified for new pavement construction in sawed transverse joints, sawed longitudinal joints, and all expansion joints. Hot-poured elastic joint sealers are specified to fill longitudinal and transverse construction joints, and joints between pavement and shoulders and fixed objects such as box inlets, manholes, retaining walls, concrete barriers or similar objects. Silicone rubber sealants are usually reserved for use in pavement restoration projects. It should be noted that specifications relative to silicone sealants for concrete pavements, as contained in Special Provision 63G (88), are now voided. The contents of Special Provision 63G (88) have been incorporated into the 1991 Kentucky Department of Highways' Standard Specifications for Road and Bridge Construction subsection 501.23.03.

It may be concluded from this study that utilization of proper construction and specified installation techniques will ensure an effective joint seal that will prevent moisture and incompressible fines from entering the pavement joint. Based on this successful initial application of self-leveling silicone rubber sealants for new portland cement concrete pavements and the excellent short-term performance exhibited thus far by both silicone rubber sealants, future uses of the silicone rubber sealant materials are warranted and recommended. Self-leveling silicone rubber and silicone rubber sealants for cement concrete pavement joints should be specified for some additional new construction projects on a limited, experimental basis. Additional experimental projects will permit supplemental documentation of the historical performance of the sealant materials used to seal cement concrete pavement joints. Self-leveling silicone rubber sealants are also recommended for limited, experimental use in cement concrete pavement restoration projects as detailed within subsection 501.23.03 of the Kentucky Department of Highways' Standard Specifications for Highway and Bridge Construction. Self-leveling sealants used in this manner will allow performance comparisons with traditional silicone rubber sealant materials.

REFERENCES

1. Ray, Gordon K., "Effect of Defective Joint Seals on Pavement Performance," Transportation Research Record 752, National Academy of Sciences, Washington D.C., 1980.
2. Standard Specifications for Road and Bridge Construction, Kentucky Department of Highways, Kentucky Transportation Cabinet, Frankfort, Kentucky, 1991 Edition.

APPENDIX A

Joint Sealer Specifications

and

Installation Requirements

DOW 888 Silicone Sealant and DOW 888 SL (Self Leveling) Silicone Sealant

The Dow Corning 888 and 888 SL silicone joint sealants are a one part, cold-applied silicone material that can be installed over a wide range of temperatures. The silicone material is used exclusively in concrete-to-concrete joints that undergo a high degree of movement. The silicone cures upon exposure to atmospheric moisture and forms a permanently flexible, low-modulus, high-elongation silicone rubber joint seal. The DOW 888 product can be used both vertically and horizontally and requires tooling. However, since the 888 SL is self-leveling, it cannot be used on vertical surfaces and requires no special tooling. Material requirements for DOW 888 and DOW 888 SL are given in Table A1. Kentucky specifications and requirements for silicone sealants (non-self leveling) are contained in Article 807.02.05 of the 1988 edition of the Kentucky Department of Highways' Standard Specifications for Road and Bridge Construction and are provided in Table A1. Installation requirements for silicone sealers for cement concrete pavements are contained in Kentucky Department of Highways' Special Provision No. 63G (88) (included in Appendix A). Kentucky Department of Highways Standard Drawing Number RPX-020-02 illustrates the joint detail for silicone rubber seals for cement concrete pavements (included in Appendix B).

TABLE A1. MATERIAL REQUIREMENTS FOR SILICONE RUBBER JOINT SEALANT

Item	KYDOH Requirements	DOW 888 Specifications	DOW 888 SL Specifications
Flow, inches maximum	0.3	0.2	N/A
Extrusion rate, grams/minute	75-350	90-250	100-660
Tack free time @ 77°F +/- 3°, minutes	20-90	35-75	60, maximum
Specific Gravity	1.010-1.515	1.450-1.515	1.290-1.390
Durometer hardness, Shore A (7 days cured @ 77°F +/- 3° and 45-55% Relative Humidity)	10-25	15-25	N/A
Tensile Stress @ 150% elongation (7 days cured @ 77°F +/- 3° and 45-55% Relative Humidity), psi, maximum	45	45	13-30
Elongation: (7 days cured @ 77°F +/- 3° and 45-55% Relative Humidity), percent, minimum	800	1,200	1,300

KENTUCKY TRANSPORTATION CABINET
DEPARTMENT OF HIGHWAYS
SPECIAL PROVISION NO. 636 (88)

SILICONE RUBBER SEALANT FOR CONCRETE PAVEMENT

This Special Provision shall apply when indicated on the plans or in the proposal. Section references herein are to the Department's 1988 Standard Specifications for Road and Bridge Construction.

I. DESCRIPTION

This Special Provision covers installation procedures for a one-part silicone rubber sealant used to seal joints in portland cement concrete pavement.

II. MATERIALS

Materials shall meet requirements specified in subsection 807.02.05.

III. CONSTRUCTION REQUIREMENTS

All joints in the concrete pavement shall be sealed using silicone sealant in accordance with the requirements of this Special Provision, the plans and standard drawings, and in accordance with the written recommendations of the sealant manufacturer. No sealer shall be placed unless the temperature of the air and the pavement is 40°F or higher. All non-conflicting requirements of Section 501 pertaining to joints shall apply.

The configuration of new joints shall be in accordance with the plans and standard drawings.

All existing transverse joints to be reconstructed shall be saw cut and cleaned to a 3/4 inch minimum width before sealing with silicone rubber sealant. All existing longitudinal joints to be reconstructed shall be saw cut and cleaned to a 1/2-inch minimum width before sealing with silicone rubber sealant. If the saw cut of an existing joint is not of sufficient width to clean the joint faces, the Contractor shall resaw the joint to a width that will clean the vertical faces of the joint. All additional resawing of an existing joint to clean the faces of the joint and any additional silicone rubber required by additional resawing shall be at the expense of the Contractor. All debris and old joint sealer resulting from the sawing operation shall be removed from the pavement before it is opened to public traffic.

In order to saw the pavement to the required depth at the pavement edge it is necessary to extend the saw cut into the bituminous concrete shoulder. Edge drain construction shall be performed after sawing and sealing of the pavement so sealing of the cut in the bituminous shoulder will not be necessary. When edge drain construction is not included in the contract or an alternate construction sequence is specified, saw cuts in the bituminous concrete shoulders that will remain in the finished work shall be sealed using an asphalt-based sealant approved by the Engineer. Sealing of cuts in the bituminous shoulder shall be performed as soon as practicable after pavement sealing is completed in the adjacent lane, and shall be at no additional cost to the Department.

For the proper installation and performance of the seals it is essential that the joints be absolutely clean, dry, and frost free. All of the sawed joints shall be washed clean of all cuttings immediately after sawing by flushing with a jet of water and other tools as necessary.

After flushing, the joint shall be blown out with compressed air. When the surfaces are thoroughly dry and within 24 hours prior to sealing the joint, the joints shall be cleaned by sandblasting followed by blowing out with compressed air. If cleaned joints are not sealed within 24 hours after sandblasting they shall be re-cleaned by lightly sandblasting and again blown out using compressed air.

Joints other than freshly cut sawed joints shall be cleaned by sandblasting and other tools as necessary. All materials such as oil, asphalt, curing compound, paint, rust, sawcutting fines, and other types of foreign material shall be completely removed. After sandblasting, the joint shall be blown out with compressed air.

Compressed air shall always be supplied by an air compressor having suitable separators and traps. The compressed air shall be free of water, oil, or any other injurious substances.

Foam back-up rod shall be installed at the proper depth as shown on the standard drawings or plans. When 2 intersecting joints are to be sealed, the foam backup rod first placed shall be placed continuously through the intersection. The first placed rod may be placed low at the intersection or the second placed rod may be cut, so the top surface of the second back-up rod will be the correct depth below the pavement surface at the intersection.

If necessary, additional air blasting shall be used to completely remove any moisture, dust, or debris that has accumulated in the joint after placement of the back-up rod. The Contractor shall be responsible for determining that the joint is absolutely clean, dry, and frost-free immediately prior to placement of the sealant.

The seals shall be installed with an applicator having a built-in grooving tool and they shall be installed by pushing the seal ahead into the joint as opposed to pulling or dragging, to ensure complete adhesion to the sides of the joint. The silicone must be tooled against the joint walls after it is pumped into the joint because the sealant cannot flow into intimate contact with the joint wall. Separate tools for application and grooving will not be permitted, unless it is demonstrated to the satisfaction of the Engineer that acceptable results can be produced.

Joints shall be sealed as soon as practicable after sawing and before any vehicular traffic, except necessary construction vehicles and equipment, is allowed on the pavement. No traffic shall be allowed over the sealed joint for the period of time recommended by the manufacturer for proper adhesion or curing or until adequate adhesion and curing have been accomplished. The minimum time for curing shall be the time recommended by the manufacturer.

For each working day, 5 sample plugs will be removed at locations determined by the Engineer. The Engineer will test each plug for conformity to the geometrics specified for the joint seals. If the 5 test plugs do not conform to the geometrics specified for the joint

seals, additional plugs will be removed and will be identified as to location of the joint from where the plug was removed. The Engineer will test each plug to determine which joints are deficient. The Contractor shall remove and rework each deficient joint. After the deficient joints have been reworked, sample plugs will be removed at locations determined by the Engineer. The Engineer will test each plug for conformity to geometrics for the joint seals. The holes from the sample plugs shall be repaired by the Contractor no later than the next working day. The repairing of sample plug holes, and the removal and reworking of all deficient joints shall be at no additional expense to the Department.

IV. MEASUREMENT AND PAYMENT

When silicone rubber sealant is used for concrete pavement replacement and repair as covered by Special Provision No. 76, payment for joint sealing will be as specified in Special Provision No. 76.

Unless Special Provision No. 76 is applicable or unless otherwise noted in the proposal, no separate measurement or payment will be made for work or materials required to furnish and install silicone rubber sealant in accordance with this Special Provision, as this is considered incidental to the contract unit price for PCC pavement.

APPROVED


R. K. CAPITO, P.E.
STATE HIGHWAY ENGINEER

12/16/82
DATE

Hot-Poured Elastic Sealant

Hot-poured elastic joint sealer is composed of a mixture of materials that forms a resilient and adhesive compound capable of effectively sealing joints and cracks in concrete and asphaltic pavements against the infiltration of moisture and foreign material throughout repeated cycles of expansion and contraction with temperature changes, and will not flow from the joint or be picked up by vehicle tires at ambient temperatures. Material specifications, physical requirements, and installation procedures for hot-poured elastic joint fillers conform to ASTM D 3405 specification as defined in Article 807.02.01 of the 1988 edition of the Kentucky Department of Highways' Standard Specifications for Road and Bridge Construction. Briefly, the physical requirements for the hot-poured elastic joint sealer cover safe heating temperature, penetration, flow, bond, resilience, and asphalt compatibility. Because the hot-poured elastic sealer was used to seal cement concrete pavement joints, the asphalt compatibility requirement will not be discussed further.

The safe heating temperature is the highest temperature at which the material can be heated without damaging the material and is set forth by the manufacturer of the material. The pouring temperature of the material is equal to the safe heating temperature. Penetration, measured at 77°F, is equal to or less than 90. Flow, measured at 140°F, is equal to or less than 3.0 millimeters. The bond of the material refers to the ability of the material to withstand tests conducted at -20°F, in accordance with ASTM D 3407, without exhibiting cracking, separation, or other opening that at any point is greater than 1/4 inch. The resilience, or recovery, of the material must be equal to or greater than 60 percent when tested at 77°F.

Use and application requirements for hot-poured elastic joint sealers for cement concrete pavements are also contained in ASTM D 3405. These requirements concern the method of heating the sealer material, preparation of the pavement joint surface, use of a backer material, and sealer depth below the surface. The sealer material should be heated to the safe heating temperature in a kettle or melter constructed as a double boiler, with the space between the inner and outer shells filled with a heat-transfer medium such as oil. Care should be taken to not overheat the material as damage could occur. Flow in excess of 3.0 millimeters indicates the material has been damaged. Positive temperature control, mechanical agitation, and recirculating pumps are to be provided.

Pavement joints in new construction should be dry, clean of all scale, dirt, dust, curing compound, and other foreign matter. The joint faces are then thoroughly sandblasted, blown clean of loose sand by high-pressure air. The pavement joints are sealed using a melter-applicator. The use of a backer material is recommended to control the depth of sealant and achieve the desired shape factor, and to support the sealer against indentation and sag. Joints should not be overfilled with the sealer material. Joints should be filled from 1/8 to 1/4 inches below the adjacent pavement surface.

Kentucky Department of Highways Standard Drawing Number RPX-015 illustrates the pavement joint detail for hot-poured elastic sealant for cement concrete pavements (see Appendix B).

Preformed Compression Joint Sealers with Lubricant Adhesive

Preformed compression joint sealers consists of a multiple web design and functions only in compression of the seal between the faces of the pavement joint with the seal folding inward at the top to facilitate compression. The seal is installed with a lubricant adhesive and is designed to seal the joint and reject incompressibles. Specifications for the preformed compression seals and adhesive lubricant are contained in Section 807.02.03 of the 1988 edition of the Kentucky Department of Highways' Standard Specifications for Road and Bridge Construction. The preformed compression joint seals conform to ASTM D 2628 with the follow exceptions:

(1) The shape or configuration of the sealers are subject to the approval of the Department's Division of Materials.

(2) The sealers are of a design and cross section so as to be substantially solid when fully compressed. The point at which a sealer is defined as being fully compressed is also defined as closure of the sealer. Closure of the sealer should occur within a deflection range of 50 to 70 percent of the original width of the sealer.

(3) Sealers should be accurately marked at one-foot intervals by the manufacturer.

(4) Sealers should be designed so that when fully compressed, the center portion of the top surfaces will not protrude upward above the original elevation of the sealer.

(5) Sealers are subjected to a compression-deflection test in conformity with Kentucky Method 64-409. The sealer should display a minimum force per unit area of 3 pounds per square inch at 15 percent deflection and a maximum force per unit area of 40 pounds per square inch at 50 percent deflection.

(6) Sealers are subjected to a compression-shear test in conformity with Kentucky Method 64-410. The sealer should display a minimum resistive force per cubic inch of 0.5 pound to breaking away from the plates and a minimum resistive force per cubic inch of 1.0 pound to vertical displacement.

(7) The size of the sealer for the various joint widths are as follows:

(a) The size of sealer used in portland cement concrete pavement should comply with the standard drawing.

(b) The uncompressed depth of the sealer should be at least equal to the uncompressed sealer width, unless the design of the sealer prevents twisting or misalignment of the sealer during and after installation.

The lubricant adhesive must be compatible with the sealer, concrete and steel. The lubricant adhesive must meet the following KYDOH requirements:

Percent Solids by Weight - 24% minimum

Bond Extension - 5%

Weight Per Gallon - 7.2 pounds minimum

Particle Size - 0.015 inches maximum

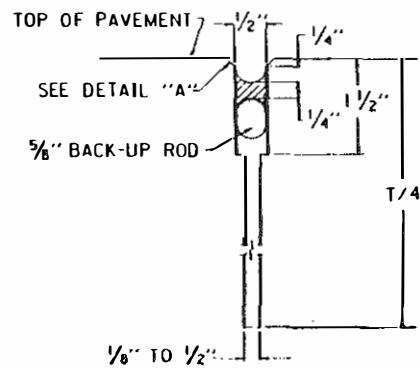
Installation of preformed compression joint sealers with lubricant adhesive is detailed in Article 501.23.02 of the 1988 edition of the Kentucky Department of Highways' Standard Specifications for Road and Bridge Construction. All joints are sealed as soon as practicable and before the pavement is opened to traffic. Before the sealer is applied, the joints are completely cleaned of loose scale, laitance, oils, greases, dirt, and other foreign substances, and all free water and loose particles are to be removed by jetting with compressed air. Kentucky Department of Highways Standard Drawing Number RPX-010-01 illustrates the joint detail for preformed compression joint seal for cement concrete pavements (see Appendix B).

APPENDIX B

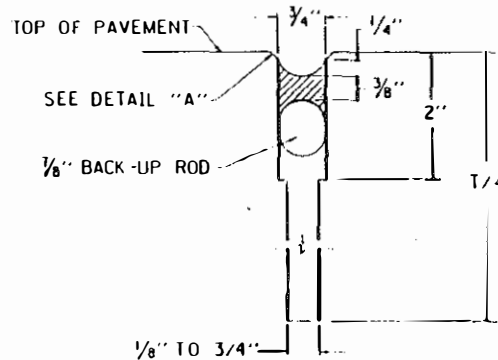
Cement Concrete

Pavement

Joint Details



JOINT SHAPE FOR
TRANSVERSE SAWED CONTRACTION JOINT
(WHEN SLAB LENGTH DOES NOT EXCEED 25'-0")



JOINT SHAPE FOR
TRANSVERSE SAWED CONTRACTION JOINT
(WHEN SLAB LENGTH EXCEEDS 25'-0")

T = PAVEMENT THICKNESS.

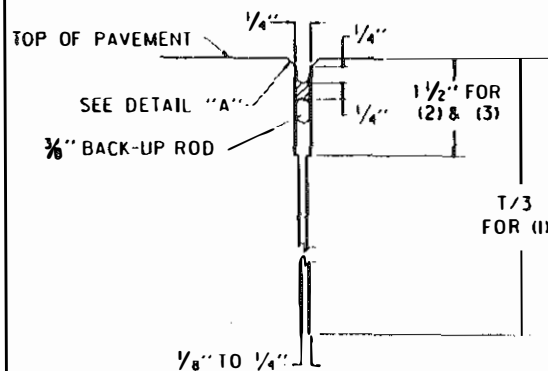
PAYMENT FOR WORK SHALL BE INCIDENTAL TO THE UNIT PRICE
FOR SQ. YD. OF PAVEMENT.

- (1) THE REMAINING JOINT SHALL BE IN ACCORDANCE WITH
CURRENT STD. DWGS. RPS-02Q AND RPS-010.
- (2) THESE EDGES SHALL BE BEVELED USING A CUTTING OR
GRINDING DEVICE.

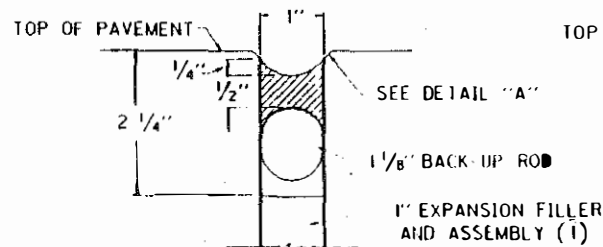
JOINT TOLERANCES : SAW CUT DEPTH -0" TO + 1/2"

SAW CUT WIDTH -0" TO + 1/16"

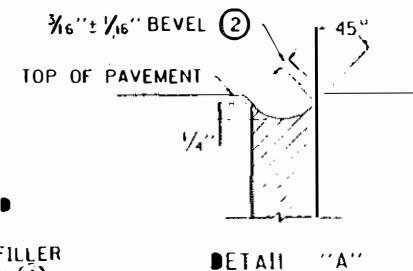
SEAL BEAD THICKNESS -0" TO + 1/8"



JOINT SHAPE FOR
(1) LONGITUDINAL SAWED JOINT (TIED)
(2) LONGITUDINAL SAWED CONSTRUCTION JOINT (TIED)
(3) TRANSVERSE SAWED CONSTRUCTION JOINT (TIED)



JOINT SHAPE FOR
TRANSVERSE EXPANSION JOINT



KENTUCKY	
DEPARTMENT OF HIGHWAYS	
SILICONE RUBBER SEALS	
FOR	
PORTLAND CEMENT	
CONCRETE PAVEMENT	
STANDARD DRAWING NO. RPX-020-02	
SUBMITTED	8-31-82
APPROVED	8-31-82

3/16" x 1/16" BEVEL (3)

45°

TOP OF PAVEMENT

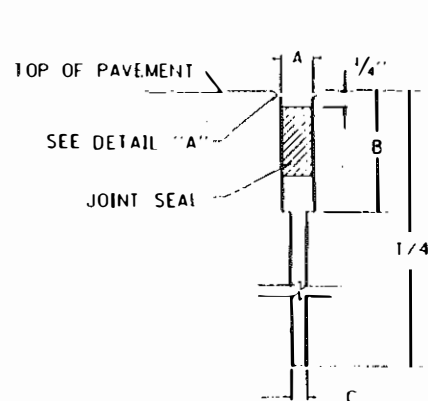
DETAIL "A"

-
- TOP OF PAVEMENT
- SEE DETAIL "A"
- JOINT SEAL
- (4)
- $\frac{1}{4}"$
- $1\frac{1}{2}"$ FOR
(2) & (3)
- $T/3$
FOR (1)

1" EXPANSION FILLER AND ASSEMBLY (1)

1/4" 1" TOP OF PAVEMENT SEE DETAIL "A"

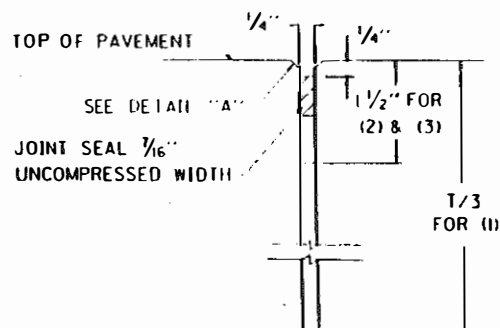
- | | | |
|-----------------------------------------------------------|--------------------------------------------------------|--------|
| KENTUCKY
DEPARTMENT OF HIGHWAYS | | |
| HOT-POURED ELASTIC
JOINT SEALS FOR
CEM. CONC. PVMT. | | |
| STANDARD DRAWING NO. RPX-015 | | |
| APPROVED | <i>James H. Bell</i>
DIRECTOR, DIVISION OF HIGHWAYS | 851 87 |
| APPROVED | <i>Blair</i>
STATE ENGINEER, DIVISION | 100 12 |



JOINT SHAPE FOR
TRANSVERSE SAWED CONTRACTION JOINT

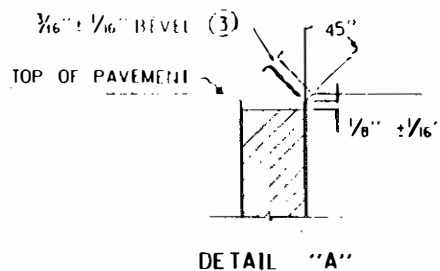
JOINT SPACING	DIMENSIONS			SEAL WIDTH UNCOMPRESSED
	A	B	C	
★ 15'-0"	3/8"	2"	1/8" TO 3/8"	1 1/16"
25'-0"	1/2"	2"	1/8" TO 1/2"	1"
50'-0"	3/4"	2"	1/8" TO 3/4"	1 1/4"

★ AVG. OF 15'-0", ACTUAL SPACING 12'-13'-17'-18'

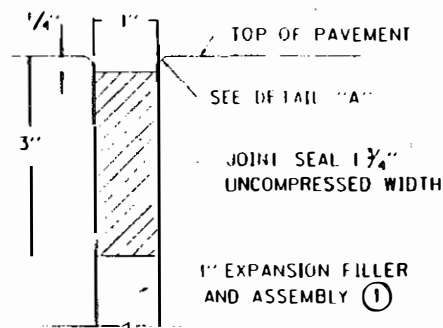


JOINT SHAPE FOR

- (1) LONGITUDINAL SAWED JOINT (TIED)
(2) LONGITUDINAL SAWED CONSTRUCTION JOINT (TIED) (2)
(3) TRANSVERSE SAWED CONSTRUCTION JOINT (TIED) (2)



DETAIL "A"



JOINT SHAPE FOR
TRANSVERSE EXPANSION JOINT

- NOTES -

PAYMENT FOR ALL WORK SHALL BE INCIDENTAL TO THE UNIT PRICE BID PER SQ. YD. OF PAVEMENT.

TOLERANCES ON ALL JOINT WIDTH DIMENSIONS PLUS OR MINUS 1/16".

INSTALLATION OF PREFORMED POLYCHLOROPRENE SEALS SHALL BE IN ACCORDANCE WITH ARTICLE 501.23.02 OF THE 1988 STANDARD SPECIFICATIONS, EXCEPT TRANSVERSE EXPANSION JOINTS SHALL RECEIVE PREFORMED SEALS IN ACCORDANCE WITH THIS DRAWING.

- (1) THE REMAINING JOINT SHALL BE IN ACCORDANCE WITH CURRENT STD. DWG. RPS-010 AND RPS-020.
- (2) ALL LONGITUDINAL AND TRANSVERSE SAWED CONSTRUCTION JOINTS SHALL BE CUT TO THE DEPTH SHOWN AND SHALL BE SEALED WITH HOT POURED ELASTIC JOINT SEAL.
- (3) THESE EDGES SHALL BE BEVELED USING A CUTTING OR GRINDING DEVICE.

T = PAVEMENT THICKNESS.

KENTUCKY DEPARTMENT OF HIGHWAYS	
PREFORMED COMPRESSION JOINT SEAL FOR CEM. CONC. PVMT.	
STANDARD DRAWING NO. RPX-010-01	
DESIGNED BY <i>James S. Blain</i>	8.31.87
CHECKED BY <i>2/2/88</i>	2.2.88
APPROVED BY <i>1/1/88</i>	1/1/88

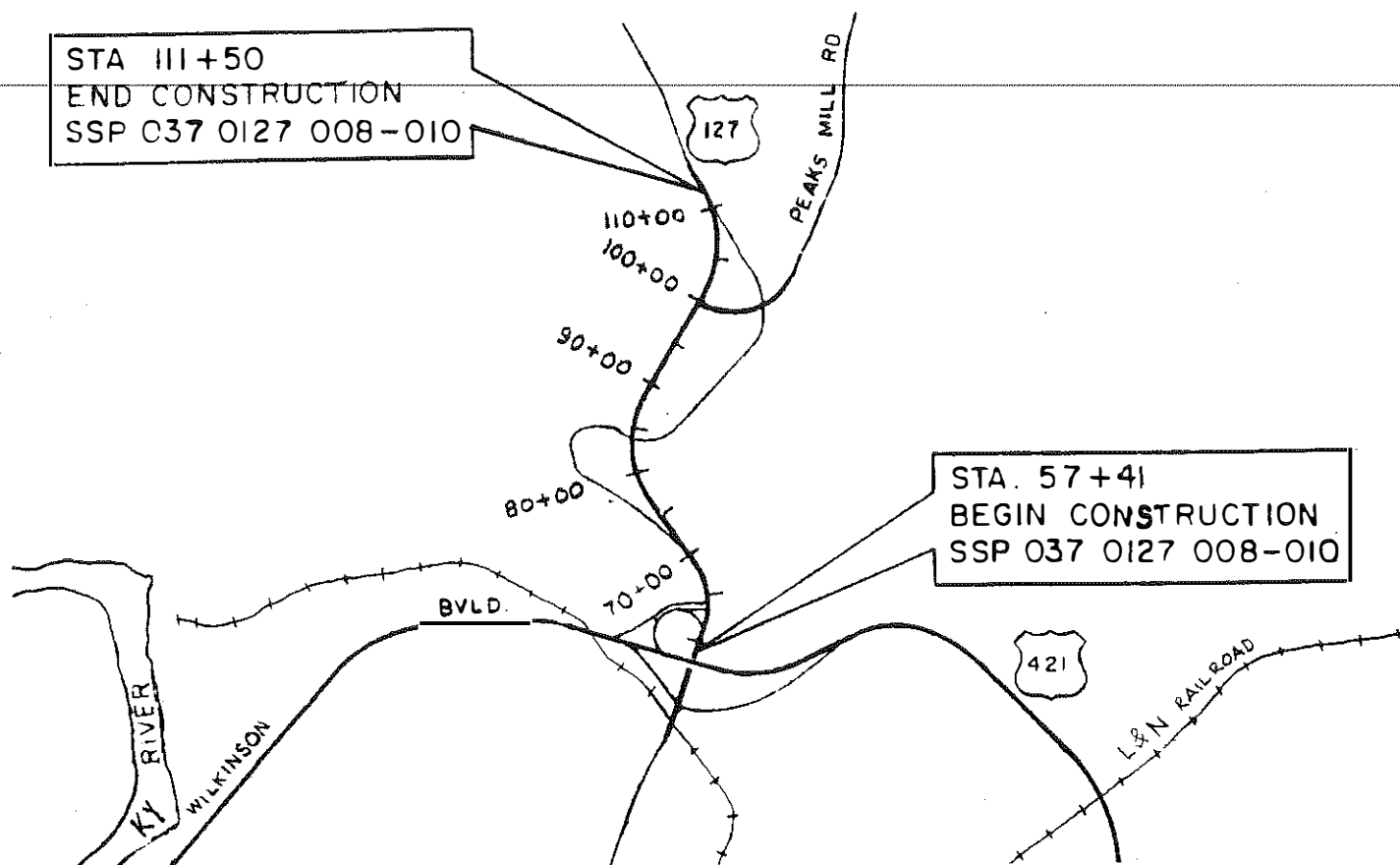


Figure 1. *Location of project.*

concrete pavement extending from Station 66+50 to Station 107+50. A large portion of the experimental site was located on a seven percent grade. The subcontractor, Shamrock Construction Company, was responsible for placement of the cement concrete, sawing and cleaning of the cement concrete pavement joints, and sealing the cement concrete pavement joints. The jobsite was divided into two sections. Section one was located between Station 85+50 and Station 107+50. Section two extended from Station 66+50 to Station 85+50. Placement locations for the different materials are given in Table 1. Construction of the concrete pavement took place during the early summer months of 1990.

The cement concrete pavement was placed, finished, cured, and joints were sawed to control shrinkage cracking. The pavement joints then were re-sawn to the correct joint size prior to installing the cement concrete pavement joint sealers. Typically, longitudinal pavement joints were sawn 1/4-inch wide and transverse joints were sawn 1/2-inch wide. All construction joints were 5/8-inch wide. The installation procedures that followed this activity varied for the different joint treatment material types and are described herein.



Figure 2. *Wheel having raised center used to position backer material in the pavement joint.*



Figure 3. *Application wand used to install silicone products.*



Figure 2. *Wheel having raised center used to position backer material in the pavement joint.*



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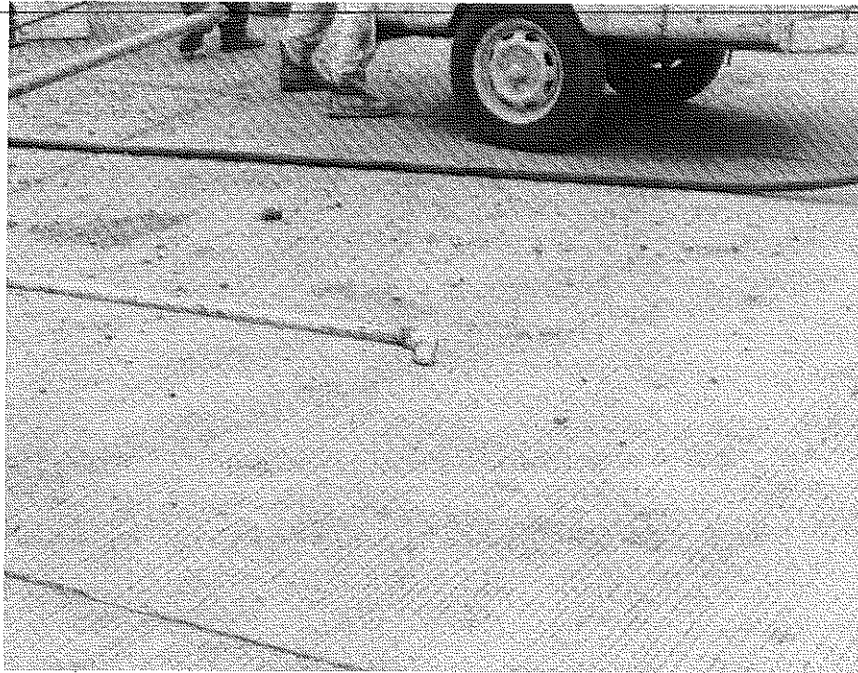


Figure 4. *Instrument used to smooth the silicone rubber sealant.*



Figure 5. *Workers sometimes used their fingers to tool the silicone rubber sealant.*

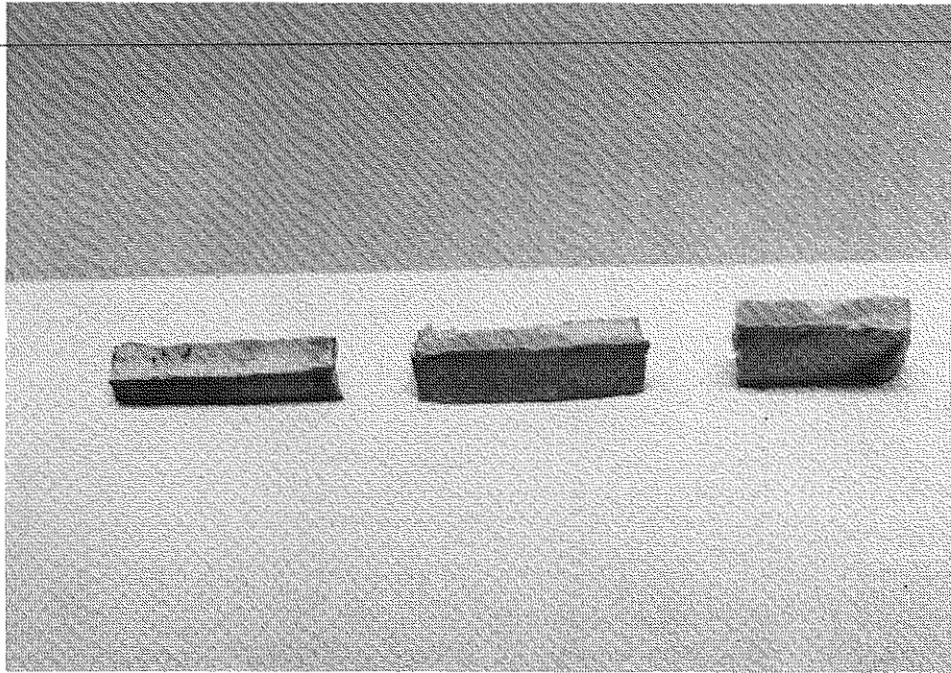


Figure 6. *Plug samples obtained from pavement joints filled with the silicone rubber sealant revealed varying sealant thicknesses.*

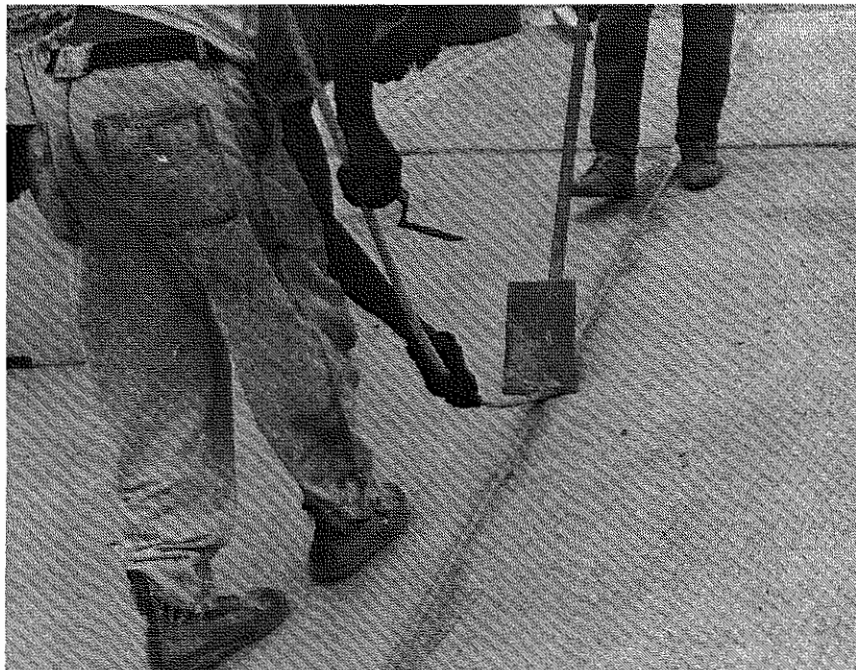


Figure 7. *Installation of the silicone rubber sealant required significant tooling and clean up.*

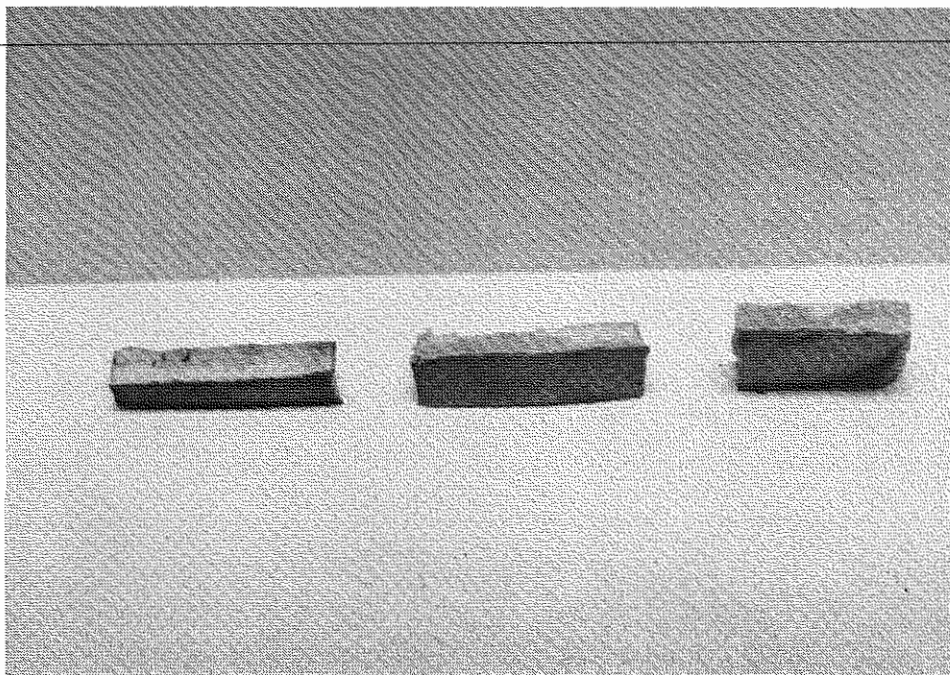


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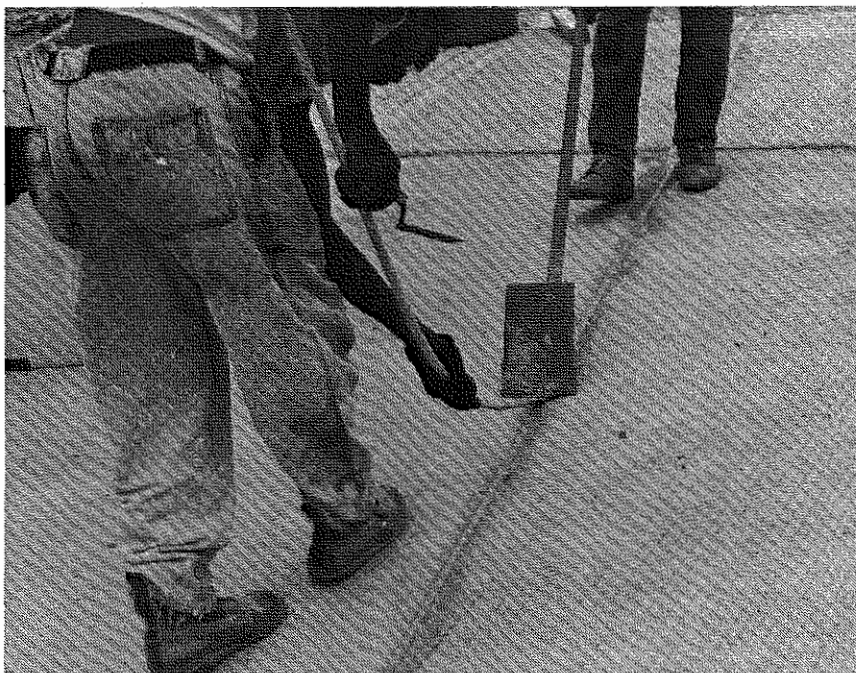


Figure 7. *Installation of the silicone rubber sealant required significant tooling and clean up.*

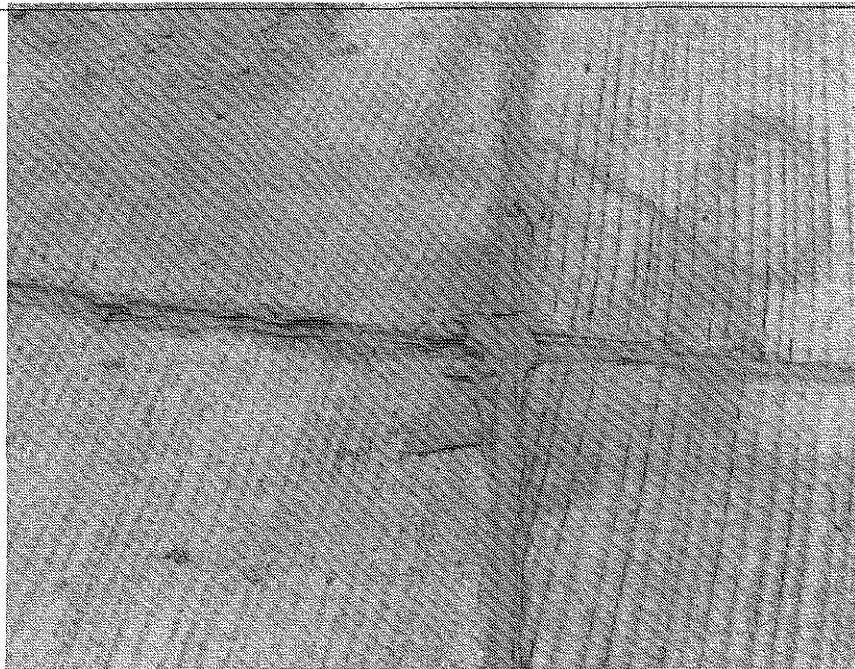


Figure 8. *Excess material in the pavement joint filled with the silicone rubber sealant.*

Hot-Poured Elastic Sealant

Hot-poured elastic sealant was used in all construction joints within the polychloroprene seal sections. The hot-poured elastic sealant was installed at a temperature of 400°F +/- 15°F. Placement of the hot-poured elastic sealant was performed by two men. One man drove the truck containing the liquid material and the other man operated the applicator. Further finishing of the hot-poured elastic sealant was not required after it was installed.

The hot-poured elastic sealant was extremely liquid during its placement. The highly liquid sealant would flow into a large void leaving the sealant too low in the pavement joint. In one instance, this problem was called to the attention of the inspector and the pavement joint was refilled to the proper depth. The hot-poured elastic sealant exhibited difficulties similar to those encountered with the silicone rubber sealant products. The rate of flow of the sealant had to be rigorously controlled or the installation appeared ineffective. In many of the construction joints, the hot-poured elastic over filled the joint and no attempt was made to clean the excess material from the pavement surface.

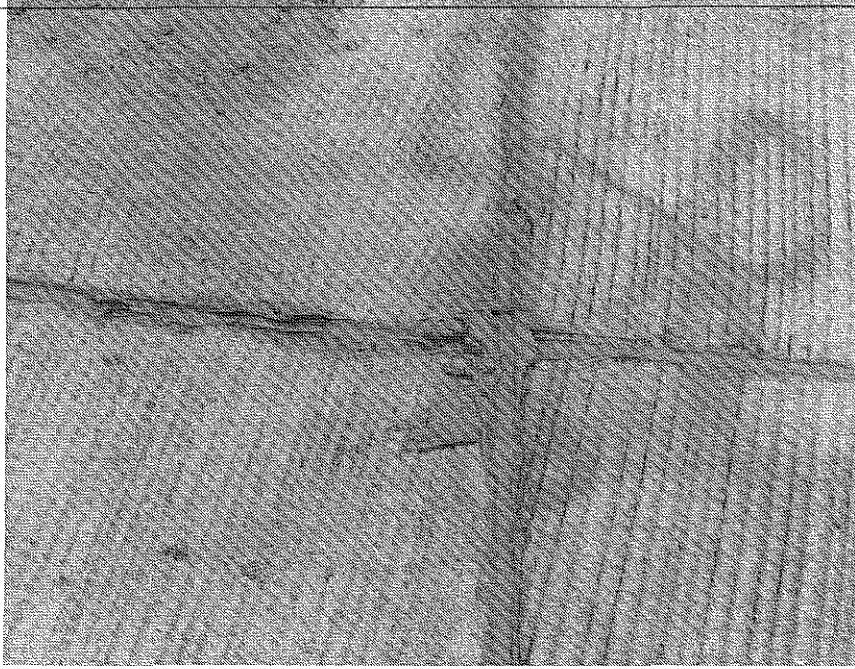


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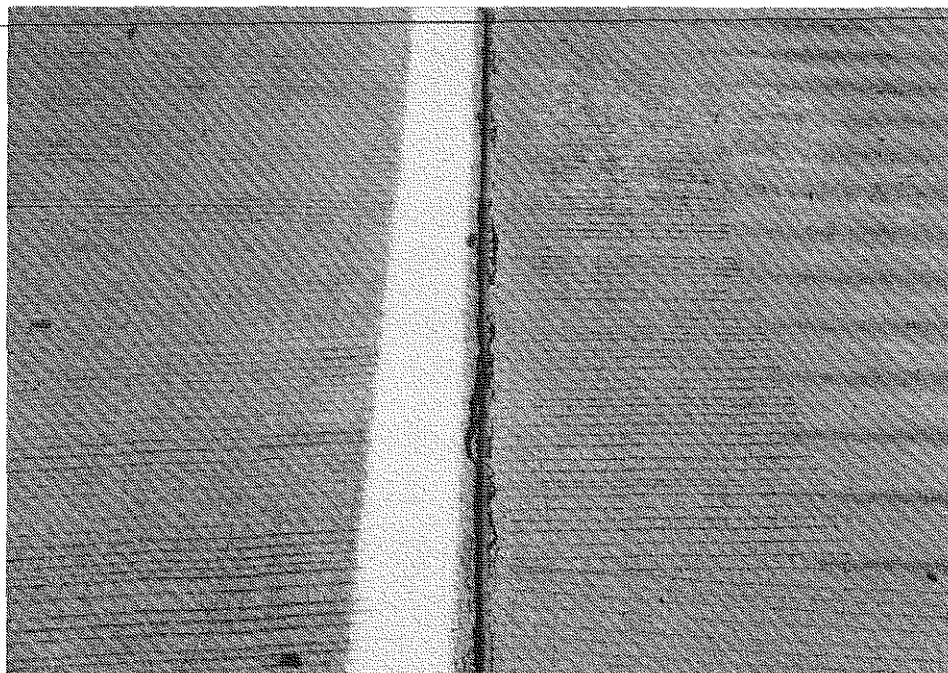


Figure 9. *Deterioration of construction joint near Station 91+00. Pavement joint is filled with self-leveling silicone rubber sealant.*

Remedial work should be performed to prevent surface water and fine incompressible material from entering the construction joint. Figure 10 illustrates a deteriorated transverse construction joint in the southbound lanes near Station 93+00 in the section containing pavement joints filled with silicone rubber sealant. Another type of failure was observed in an area where corrective work had been performed so that the concrete pavement would meet pavement smoothness requirements. Unfortunately, as shown in Figure 11, this grinding action on the pavement surface initiated deterioration of the pavement joint and destroyed the integrity of the silicone rubber sealant. According to subsection 501.23.01 of the Kentucky Department of Highways' Standard Specifications for Road and Bridge Construction, smoothness requirements must be met prior to placing any joint seals on new portland cement concrete pavement unless otherwise permitted in writing, which must have occurred on this project. Remedial work should be performed within those pavement areas that were ground to meet smoothness requirements so as to restore the effectiveness of the pavement joint sealant.

The overall appearance and performance of the self-leveling silicone rubber sealant is, to date, superior to the comparative sealant materials. The self-leveling silicone rubber

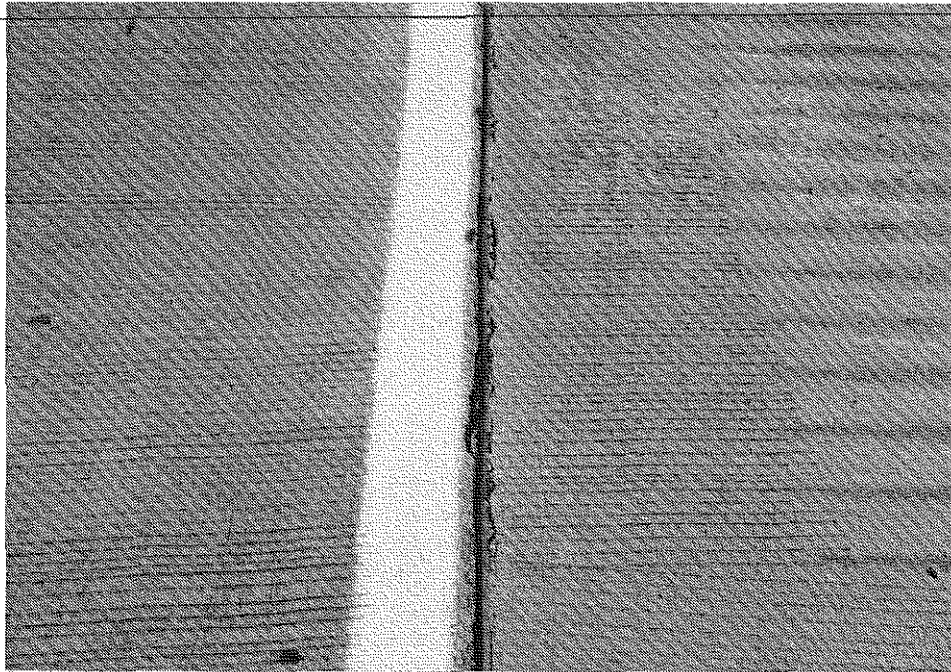


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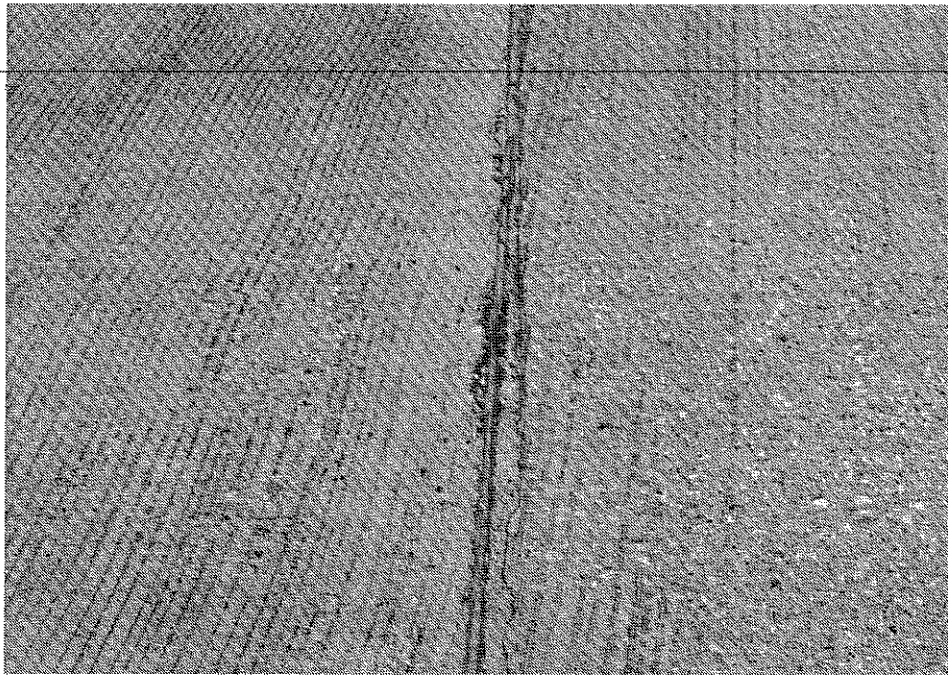


Figure 10. *Deterioration of transverse construction joint filled with silicone rubber sealant near Station 93+30.*

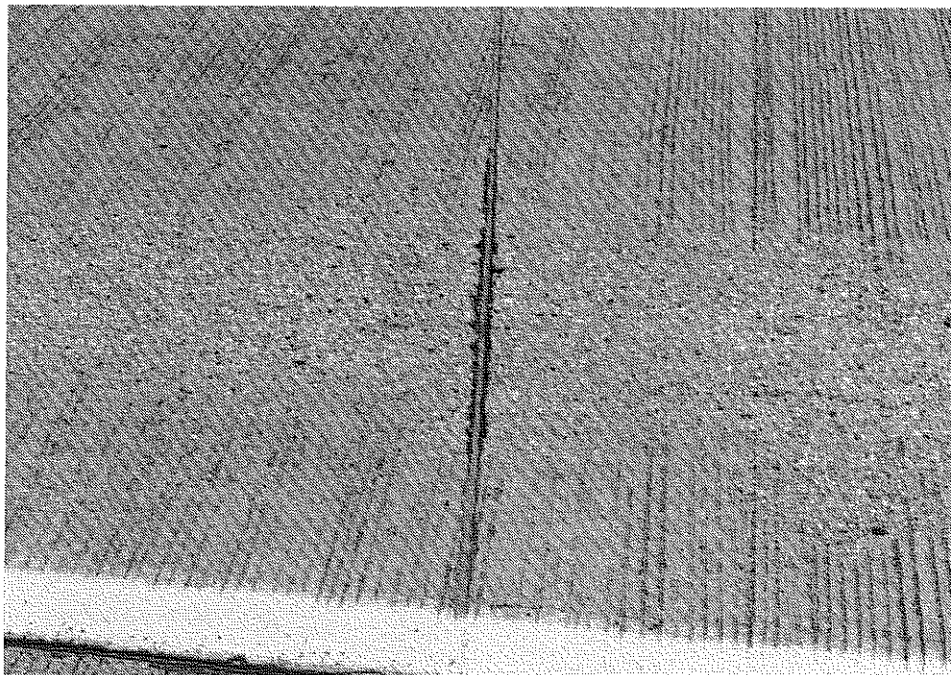


Figure 11. *Deterioration of a transverse joint filled with self-leveling silicone rubber sealant due to corrective work performed on the pavement surface near Station 100+20.*

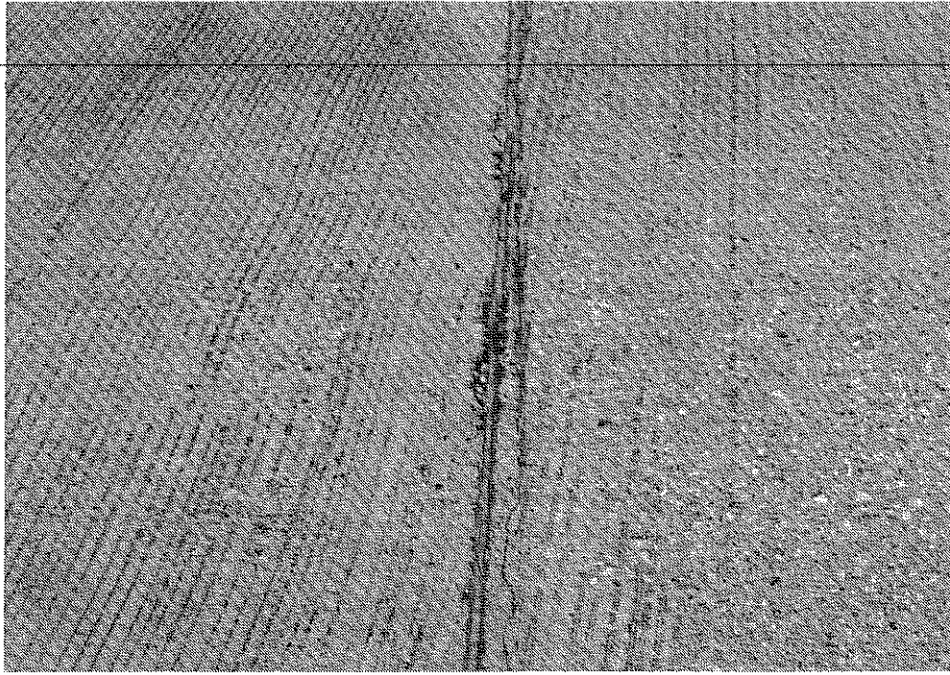


Figure 10. *Deterioration of transverse construction joint filled with silicone rubber sealant near Station 93+30.*

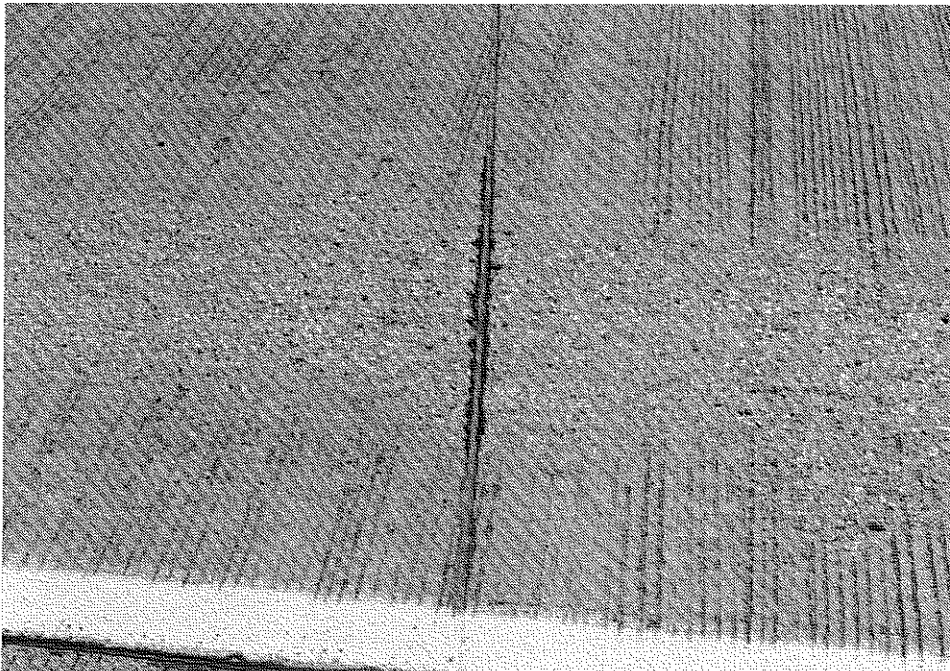


Figure 11. *Deterioration of a transverse joint filled with self-leveling silicone rubber sealant due to corrective work performed on the pavement surface near Station 100+20.*

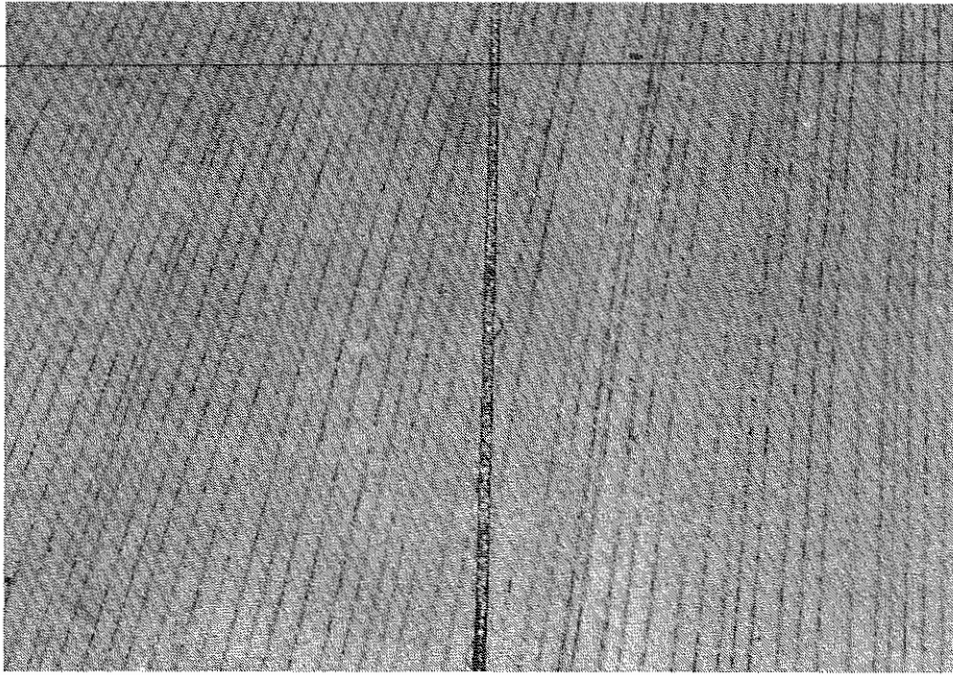


Figure 12. *Pavement joints having polychloroprene compression seals exhibit a large accumulation of incompressible fines.*

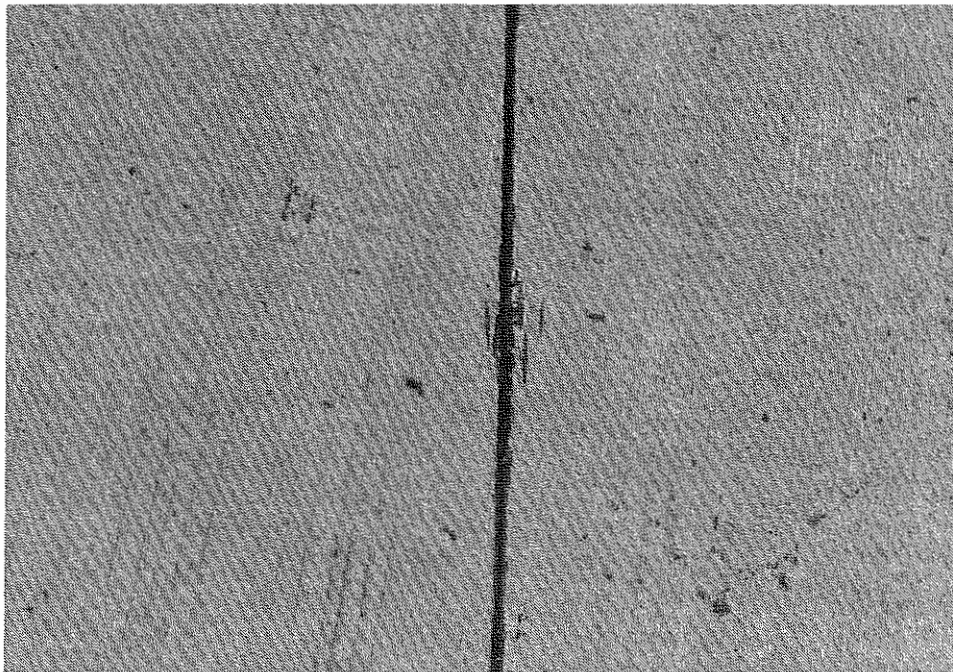


Figure 13. *This polychloroprene compression seal was twisted within the pavement joint.*

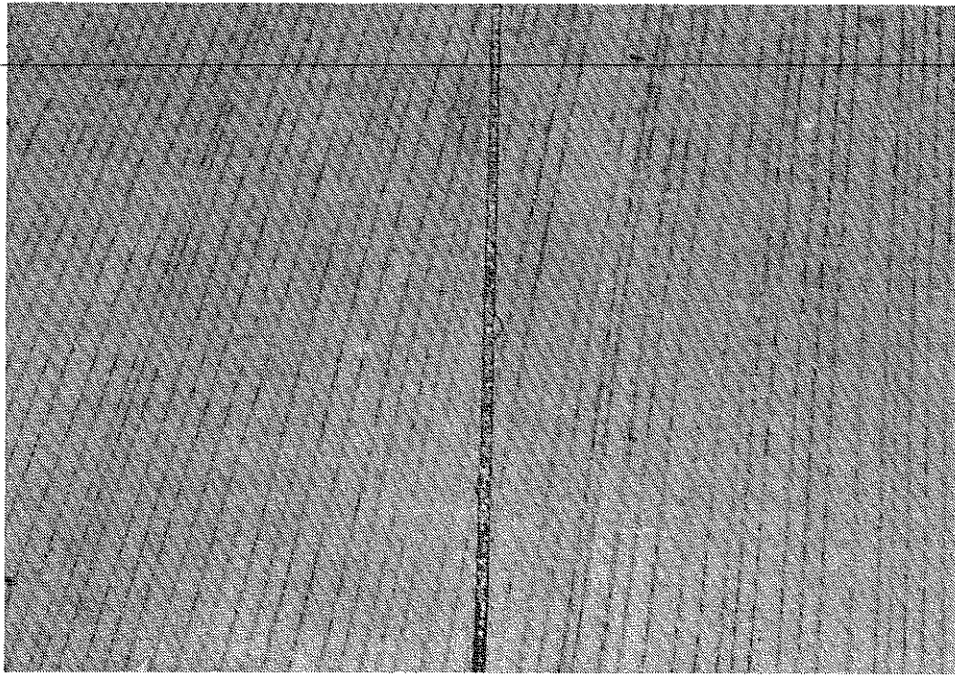


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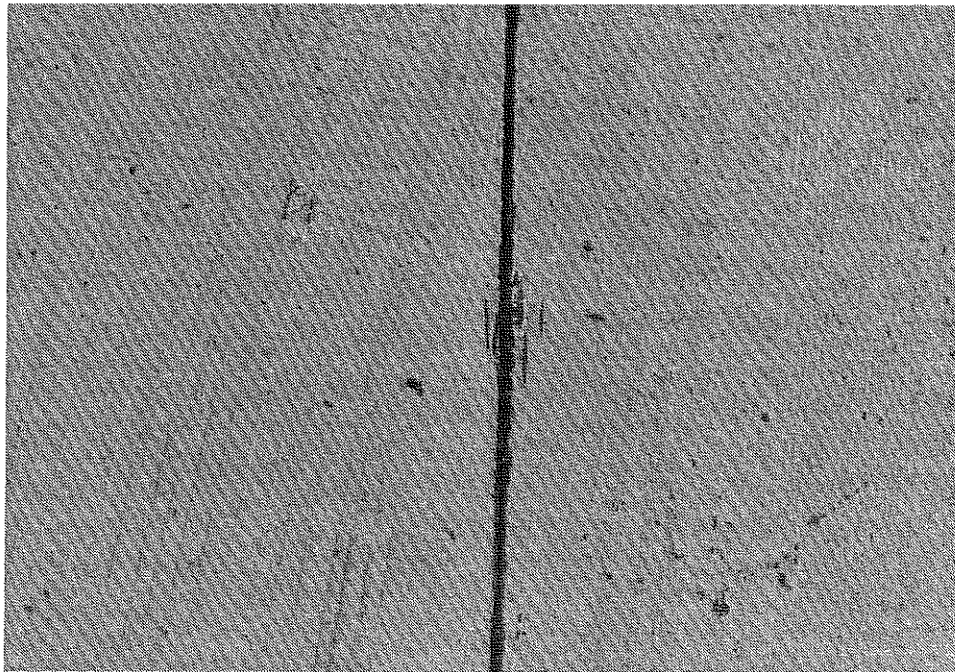


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The appearance of the hot-poured elastic joint sealer is not satisfactory due to the depth from the surface in some areas and material overruns in other areas (see Figure 14). However, the hot-poured elastic sealer appears to be performing effectively and continues to be very pliable nearly three years after installation. It should be reiterated that the hot-poured elastic sealer is located only in construction joints within the polychloroprene compression seal sections. The hot-poured elastic sealant generally will not be subjected to the traffic action as that of other sealant products.

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The Kentucky Transportation Center was contracted by the Kentucky Department of Highways to evaluate the installation and short-term performance of four different types of joint sealants used for portland cement concrete pavements. The four cement concrete pavement joint sealers used in the project were: silicone rubber sealant, self-leveling silicone rubber sealant, preformed polychloroprene compression seals, and conventional hot-poured elastic sealant.



Figure 14. *The hot-poured elastic sealant was observed to overfill and underfill the pavement construction joint.*

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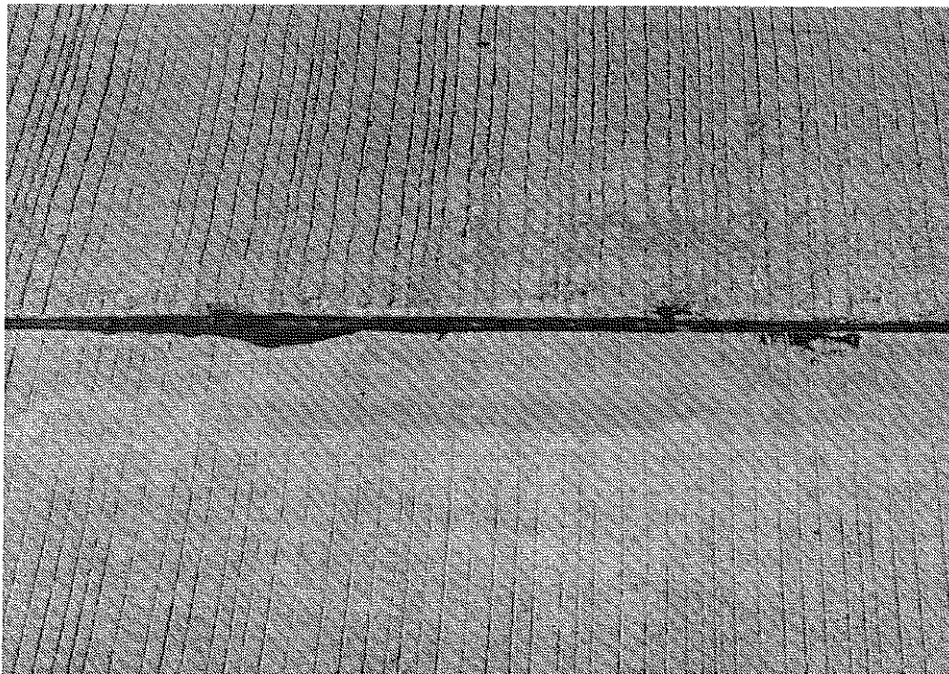


Figure 14. *The hot-poured elastic sealant was observed to overfill and underfill the pavement construction joint.*

The silicone rubber sealant was sticky, difficult to install properly, and subsequently, is displaying evidence of increased wear. The self-leveling silicone rubber sealant was less viscous, less sticky, easier to install, obtained the correct depth in the joint most consistently, and has performed extremely well to date. The preformed polychloroprene compression seals appeared to be easily installed. However, uniformity in depth below the surface of the joint was not achieved and some twisting of the seals has occurred. The preformed polychloroprene compression seals are not revealing any signs of increased wear. Nevertheless, more incompressible materials are collecting in those pavement joints that contain the preformed polychloroprene compression seals. Twisting failures of the compression seals also have been observed. The hot-poured elastic joint sealer was easily installed but installers had difficulties achieving the desired depth within the pavement joint. The hot-poured elastic joint sealer has not exhibited any evidence of significant wear thus far. Figure 15 illustrates one advantage of using field-molded sealants as opposed to preformed sealants. Human error, when re-sawing the joint, resulted in a non-specification joint width. The silicone sealant provides an effective seal whereas the compression seal would not in this instance.

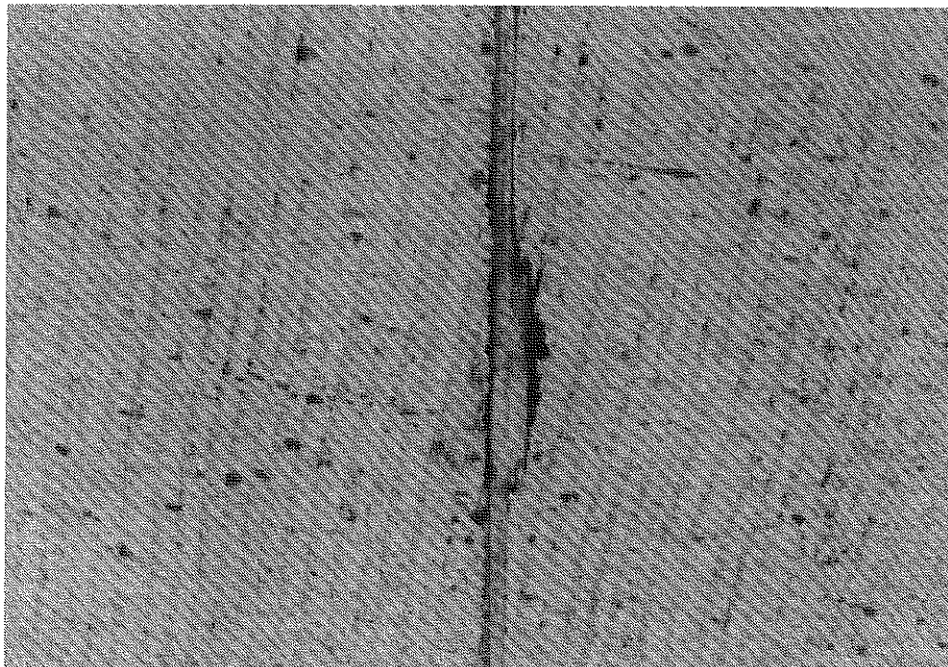


Figure 15. *Field-molded sealants may overcome deficiencies of non-specification joint widths.*

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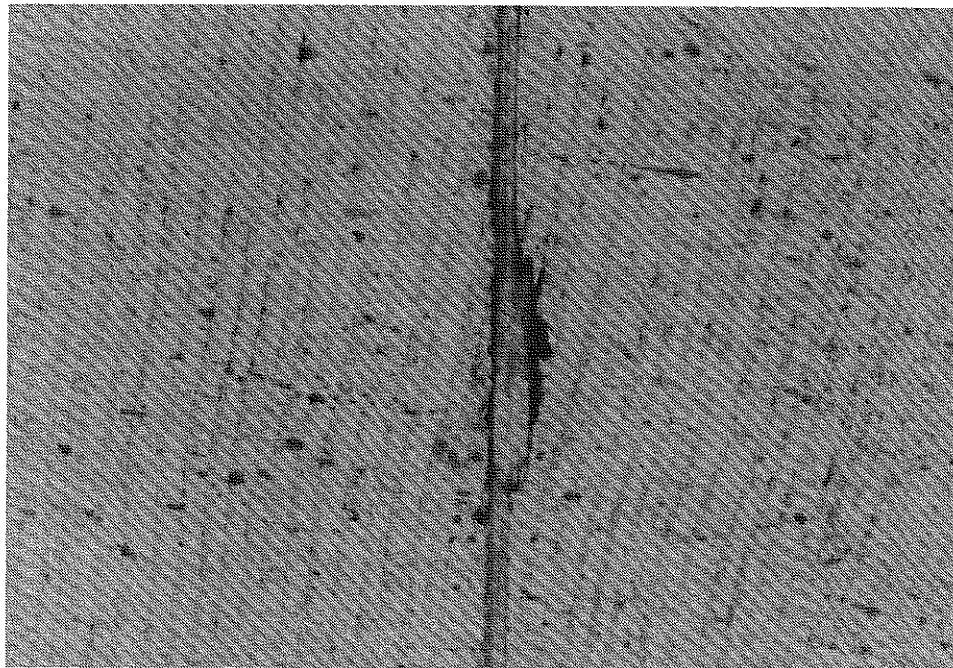


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